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ORIGINAL ARTICLES.

I.—On Dikes of Oligocene Sandstone in the Neocomian Clays of the District of Alatyr, in Russia.

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(PLATE V.)

THE part of the province of Simbirsk lying to the north of Alatyr, in the angle between the Soura and the Alatyr rivers, is formed of Lower Cretaceous strata, chiefly Neocomian clays, covered by Boulder-clay (which is not rich in boulders), and part by Glacial and Æolian sands. The same Neocomian clay expands widely to the south and to the east from the town of Alatyr. Upon the northern border of the Alatyr valley, and on the right side of the Soura river, these clays are covered by ancient alluvial sands, deposited probably at the time when the great ice-sheet dammed the course of the Soura in the lower part of its valley, and caused colossal overflowings of its waters, the traces of which are preserved in the great masses of alluvial sands covered with fir wood, and much resembling the "Haidesand" of Northern Germany.

Only to the south-west of Alatyr, at a distance twenty kilom., commences the region of the Upper Cretaceous beds, covered by sands and quartz-sandstones without fossils, defined as Tertiary from their resemblance to the Tertiary sands and sandstones of the southern parts of the province of Simbirsk. A small outlier of these sands is preserved also at a point to the north-west of Alatyr at the same distance.

I have been well acquainted with these general features of the geological structure of the region since my geological researches in this country in 1887. In 1892 I was once more in Alatyr, during the construction of a bridge across the Soura river for the Moscow-Kazan railroad. Mr. N. Th. Ditmar, a mining engineer then attached to this railroad, had drawn my attention to the sandstone brought by the countrymen of a neighbouring village, Yavley, which they found in a ravine ending in the Soura near this village. We went with Mr. Ditmar to this ravine, which cuts, from west to east, the high left border of the Soura valley, and I saw at a distance of

about three kilos. from Yavley village a rare stratigraphical phenomenon—a vein of sedimentary rock which had filled up a nearly vertical fissure in another sedimentary rock, just as we see volcanic veins generally do.

To distinguish such veins and dikes from volcanic veins and dikes, I shall venture to call these cases by the brief appellation of Neptunic veins or Neptunic dikes.

The rock forming the Neptunic dike of Alatyr turned out to be a quartz sand mixed with glauconitic grains; the sandstone found here by the countrymen once formed a dike jutting out towards the ravine, and was only the locally indurated portions of this sand. At the time of my visit all these indurated portions of the dike had been already worked out. The remaining vein of sand, or very friable sandstone, cut a horizontally stratified mass of dark grey and black Neocomian clay, containing some gypsum and occasional beds of fine glauconitic sand with pyritic nodules. The soft clays were well exposed quite up to the vein, and showed no trace of induration. The thickness of the vein varies between 12 and 14 inches, its position is nearly vertical or slightly inclined (about 10–15 degrees) towards W.S.W., and its strike is about N. 15° W., *i.e.* nearly parallel to the general direction of the Soura in the neighbouring part of its course. From the direction of the ravine and from the vein being artificially cleared away, it was possible to see the vein exposed at both sides of the ravine. To follow the direction of the vein further across the land was impossible, owing to the superficial drift, as well as to the brushwood and forest of half-grown trees which covered the neighbouring land. Fig. 1 represents the vein cropping out at the left side of the ravine, and fig. 2 the same at the right side. The countrymen told us they have found several sandstone veins in this ravine, but when I visited the place, only one was to be seen, the others being probably concealed beneath the landslips and the superficial detritus.

The sandstone got from the dike occasionally includes small fragments of dark clay detached from the rock forming the walls of the dike, and is rather rich in fossils, well preserved but difficult to get from the hard rock. Shells of *Pectunculus* predominate among them.

I have previously defined, in 1892, a small number of species as characteristic of the Lower and partly Middle Oligocene.[1] Since that time our knowledge of the Lower Oligocène Mollusca has been much increased, especially by the publication of the last parts of the important Monograph of Prof. A. von Koenen,[2] and it has been possible for me to verify and rectify my former determinations; and, moreover, last summer I have had an opportunity of showing the fossils of this sandstone to Prof. A. von. Koenen, and of

[1] Comptes rendu des travaux du Comité Geologique en 1892, p. 10. Bull. du Comité Geologique, T. xii.

[2] Das Norddeutsche Unter-Oligocën und seine Mollusken-Fauna, Lief. V, 1893; Lief. VI, 1894. Abh. zur. Geol. Specialkarte v. Preussen und den Thüringischen Staaten, Bd. X. heft. 5–6.

availing myself of his advice and his large and fine collections. Prof. von. Koenen also recognized the fauna of Yavley as Lower Oligocene. I am able now to give the following list of the fossils of this fauna :

Voluta suturalis Nyst.

Pectunculus tenuisulcatus v. Koenen.

Astarte Bosqueti Nyst (v. Koenen), or another very closely allied species differing from *Astarte Bosqueti* only by the lateral teeth being somewhat shorter.

Ostrea ; many small specimens partly resembling young specimens of *Ostrea flabellula*, and partly like the young of *Ostrea Queteleti* Nyst (v. Koenen).

Nucula, cf. *Bowerbankii* Wood (non Dixon).

Natica, cf. *hantoniensis* Pilk.

Acirsa, probably a new species allied to *Acirsa angusta* (v. Koenen).

Cases are well known in which small bands of sedimentary rock have been jammed between rocks of another geological age. Such occurrences have been observed in several countries by many geologists, especially in regions broken by numerous and compound faults, as for instance, in the cases of the bands and pieces of Jurassic, Cretaceous and Tertiary rocks jammed between the Triassic rocks of Middle Germany.

The Neptunic dike of Alatyr cutting an area of undisturbed stratification cannot be compared with such tectonic wedges, to which latter, indeed, the term Neptunic dike cannot strictly speaking be applied. We are acquainted with other types of veins or pockets cutting sedimentary strata and filled by another sedimentary or fragmental mass; such are the veins and pockets in the Cretaceous Limestone between Lausanne and Yverdon in Switzerland (Poches siderolitiques of Mouremont). Of similar character are the veins and dikes in the Carboniferous Limestone of the eastern border of the Mendip Hills filled by yellow marly conglomerate with Triassic fossils. In the same country (near Holwell, about five miles from Frome) there are still more interesting dikes cutting into the Carboniferous Limestone, formed of Liassic conglomerate with marine fossils. These latter were described by Mr. Charles Moore in the Quart. Journ. of Geol. Soc., vol. xxiii, 1867. They have been considered as fissures in the Carboniferous Limestone, when that rock formed first a shore pounded by the breakers of the Liassic sea and afterwards the floor with open fissures of this Liassic ocean.

Sandstone dikes, more or less closely resembling our Alatyr dike, have been described by many authors. Thus Mr. H. Strickland (Trans. Geol. Soc. Ser. ii, vol. v, p. 599) has described four dikes penetrating into Lias shale at Ethie, near Cromarty in Ross-shire, of which two are parallel to the stratification of the Lias shale, but the other two send off branches in various directions; no fossils have been noticed in the substance of the dikes, and the period of insertion of the sand into the fissures is undeterminable. Mr.

W. Cross describes (Bull. Geol. Soc. of America, vol. v, p. 225) intrusive sandstone dikes in granite occurring in the Pikes Peak region in Colorado; no fossils were found in the sandstone, the source of sand and the time of its intrusion not being defined. Mr. J. S. Diller refers, in Bull. Geol. Soc. of America, vol. i, p. 439, to many other cases of sandstone dikes discovered in many countries (by Ch. Darwin in California, by J. D. Dana in Oregon, by T. D. Whitney in California, by W. J. McGee in eastern-central Mississipi).

The features which distinguish the Neptunic dike of Alatyr from the above-mentioned are that the rock in which it is enclosed is soft, while the rock forming the dike itself is in some places a hard sandstone, and in others a friable sand.

Our Alatyr dike more closely resembles the sandstone dikes cutting Cretaceous shales in the north-western border of the Sacramento valley in California, carefully described by Mr. J. S. Diller.[1] These sandstone dikes, which are exposed in the valleys of several streams tributary to Cottonwood creek, strike to the north-east, are more or less parallel one to another, and in cutting the shales are inclined 15° to the north-east. The thickness of these dikes varies from two to fourteen or twenty inches, and the largest dike is fifteen feet thick. The sandstone forming the dikes is more or less homogeneous, and frequently includes small fragments of shale along their borders. The shales which contain the sandstone dikes are covered by the newer formations of the Sacramento valley. In explaining the origin of these dikes Mr. Diller calls attention to certain phenomena frequently associated with earthquake movements. Thus, during the great Calabrian earthquake of 1783 many fissures were formed in the ground, and from some of them great quantities of sand and water issued. After the flow ceased, the openings were left full of sand. Similar phenomena accompanied the earthquakes of New Madrid, Missouri in 1811–1813, of Valparaiso in 1822, of Sonora in 1887, etc.

The formation of a system of parallel fissures by earthquakes, and their being filled with sand forced up from below is, according to Mr. Diller's view, a phenomenon identical with the formation of the sandstone dikes of Sacramento region, these dikes thus being a record of ancient earthquake movement. A sandy bed of the same Cretaceous series, cropping out from under the shales which are cut by the dikes, about seven miles westward of the principal group of dikes, is considered to be the source of the sand in the dikes. Thus, according to Mr. Diller's view, the sand is carried up by an ascending current of water from a lower, *i.e.* from a more ancient bed. In the absence of fossils it was scarcely possible to prove this positively.

Is such an explanation applicable to our case? We must reply in the negative. Our case makes it possible to give a somewhat different explanation. Our conditions are more favourable, fossils being preserved in the rock forming the Neptunic dike of Alatyr. It can positively be decided whether the sandstone of the dike is

[1] Bull. of the Geol. Soc. of America, 1889, vol. i, pp. 411-442.

older or newer than the rock which encloses it. The facts are that the clay cut by the dike is of Lower Cretaceous age, while the sandstone of the dike is Tertiary, or to speak more strictly, Oligocene, and therefore considerably newer. The sand must then have been intruded into the clay not from below but from above. Now let us consider what were the circumstances of the formation of the dikes.

The formation of the fissures long before their infilling and the slow accumulation of sands in them, such as may have occurred in the case of the fissures in the Carboniferous Limestone of the Mendips, cannot be considered as probable, the clay being soft and the sandstone homogeneous, and the latter having none of the characters of a slowly accumulated deposit. We must conclude, therefore, that the fissure was opened and quickly filled with the sand which was on the spot ready to fill it.

We can represent to ourselves the march of events in the region of Alatyr before and after the formation of these dikes somewhat as follows.

The Lower Cretaceous sea deposits here a thick mass of clays interstratified with beds of glauconitic sand. The existence of Gault in the neighbourhood shows that these conditions were continued also into the Gault period. We may also suppose, with all probability, that during part of the Upper Cretaceous time this was a littoral part of the sea, because the northern boundary of the Upper Cretaceous beds does not pass far from here to the south. After Upper Cretaceous times, the region becomes dry land, and the Upper Cretaceous and Gault deposits are exposed to denudation. A new transgression of the sea begins in the Lower Oligocene time, during which the Oligocene sea covers the Lower Cretaceous clays and lays down its sandy sediments on their surface. While this Oligocene sand was still not too thick, an earthquake occurs and the seismic fissures tear the floor of the sea, penetrating into the Neocomian clay; and the Oligocene sand, containing many shells, quickly fills up the fissures. After a time the level of the sea falls, the dry land reappears in the region, the process of denudation recommences, and the Tertiary strata disappear almost entirely from the country. In Quaternary times a marginal part of the great ice-sheet passes through the country, and the old alluvial sands are deposited on the lower parts, and we should never have known that the Oligocene sea once covered this region, if a little sample of its sediment had not escaped destruction by being concealed deep in the fissures of the sea floor.

If this explanation be correct, we have here an interesting instance of the means by which nature notes the events of her history. The earthquake breaks for a moment the regular march of events, and the sea with its sandy floor becomes for the occasion a seismograph, and notes this event and the time at which it took place.

II.—On a Recent Boring in the Trias at Stratford-on-Avon.

By Horace T. Brown, F.R.S., F.G.S., F.C.S.

THE question of the water supply of the town of Stratford-on-Avon has for years past presented many difficulties. The town is situated on the uppermost beds of the Upper Keuper Marls, and the water derived from the wells sunk in these gypseous marls, or from the alluvial gravel of the river valley, contains an amount of solids equal to about 170 grains per gallon, of which about 125 grains consist of calcium sulphate. Up to a very few years ago this intensely hard water was alone available for domestic and manufacturing purposes, but the main supply of the town is now derived from catchment basins and reservoirs at Snitterfield on the adjoining hills about four miles north of Stratford. In years of average rainfall a fair supply of moderately soft water is obtained from this source, but it is one which, as regards organic impurity, bears unmistakable signs of its surface origin, and during dry seasons the town supply has to be supplemented with the hard well-water I have already referred to.

Quite recently Messrs. Flower and Sons, who were in search of a further supply of water of a softer character for their Brewery, have put down an Artesian boring through the Upper Keuper Marls, and have reached the Lower Keuper Sandstone, which is found to contain an inexhaustible supply of water of excellent quality, and similar in general composition to that of the Leamington water, which is derived from the same beds nearer their out-crop, at a point about ten miles N.E. of Stratford-on-Avon.

The position of the boring is about half-a-mile to the north of the town, and is 400 yards east of the junction of the Upper Keuper with the Rhætic Beds, the line of division here running almost north and south. If this is not a faulted junction, and there is no evidence of this, the boring must commence very nearly at the top of the Upper Keuper, so that the distance from the surface of the ground to the coming in of the Lower Keuper must approximate very closely, probably within 25 or 30 feet, to the total thickness of the Upper Keuper Marls in this part of the country.

After taking into consideration all the available geological data I considered it probable that the Lower Keuper Sandstones would be reached at a depth of 550 to 600 feet. The actual depth, as will be seen from the accompanying section, was 604 feet.

The following is a detailed section of the boring taken from samples and data carefully obtained by the contractors, Messrs. E. Timmins and Sons, during the progress of the work:—

No.		Feet.
1	Red Marl	45
2	Red Marl and Gypsum	15
3	Grey Marl and Gypsum	5
4	Red Marl and Gypsum	83
5	Plastic Red Marl	58
6	Red and Grey Marl and Gypsum	10
7	Red Marl and Gypsum	9
8	Grey Marl and Gypsum	20
9	Red Marl and Gypsum with a little sand	15

No.		Feet.
10	Plastic Red Marl	25
11	Red Marlstone with beds of White Sandstone	29
12	Red Marl and Gypsum	37
13	Red and Brown Marlstone with a little Gypsum	31
14	Red Marl with a little Gypsum	13
15	Brown Marlstone	31
16	Red Plastic Marl with a little Gypsum	74
17	Mottled Red Marl with blue veins	25
18	Red and Grey Marl	21
19	Sandy Red Marl	4
20	Red Marl with Gypsum	24
21	Marlstone	30
22	Brown Sandstone	3
23	Grey Marl	3
24	Fine light-red Sandstone	10
25	Grey Marl	3
26	Fine light-grey Sandstone	4
27	Grey Sandstone	48
28	Light Red Sandstone	5
29	Light reddish-grey Sandstone	7
30	Grey Sandstone	85
31	Red Sandstone	4
32	Grey Sandstone	28
	Bore terminates in No. 32 at	804

Summarizing the above details we have.

Upper Keuper Nos. 1-21		604
Lower Keuper Nos. 22-32		
Passage Beds (Marls and Sandstone) 22-25	19 ft.	200
Sandstones 26-32	181 ft.	

The whole of the Upper Keuper was perfectly dry, but water was met with directly the Lower Keuper was touched at 604 feet. This increased in quantity as the boring penetrated further into the sandstones, and a supply of 8,000 gallons an hour is now being pumped, without any signs of exhaustion. The artesian head of the water is considerable and is sufficient to afford a natural flow of 1,800 gallons per hour at a height of 50 feet from the surface.

I here append an analysis of the water, and for purposes of comparison have also added the analysis of the water of a town well sunk in the Upper Keuper Marls.

	Bore Water Lower Keuper.	Well in Upper Keuper.
	(Grains per gallon.)	
Sodium Chloride	4·50	3·12
Sodium Nitrate	0·06	...
Sodium Sulphate	6·87	...
Sodium Carbonate	2·75	...
Potassium Sulphate	0·61	...
Magnesium Sulphate	...	6·95
Magnesium Carbonate	1·13	16·61
Calcium Nitrate	...	2·46
Calcium Carbonate	4·41	...
Calcium Sulphate	...	122·50
Silica	0·62	Trace
Alumina	0·08	Trace
	21·03	151·64
	(Parts per million.)	
Ammonia, free and saline	0·10	0·085
Ammonia, albuminoid	Faint trace	0·045
Oxygen, absorbed in three hours	0·18	0·029

Apart altogether from the question of water supply there are several points of considerable interest about this Stratford-on-Avon boring to which I must call attention.

In the first place it is noteworthy that the transition from the Lower into the Upper Keuper facies is much more abrupt than it is in Staffordshire, Leicestershire, Nottinghamshire, and other localities in which I have had an opportunity of examining the junction. As a rule there is nothing like a sharp line of demarcation between these two subdivisions of the Trias the Marls gradually becoming more predominant as we trace the beds upwards, and the Sandstones as we trace them downwards. The line of junction in mapping the beds in most parts of the country is always a more or less arbitrary one, but here at Stratford the transition from Lower to Upper Keuper is remarkably sharp, the "passage beds" (Nos. 22-25) with alternations of Marls and Sandstones, only occupying a thickness of 19 feet.

To the north and north-west of Stratford, in the neighbourhood of Henley in Arden, there is marked on the Survey maps the outcrop of certain beds of sandstone to which Mr. Howell called attention in 1859 in his Survey Memoir on the Warwickshire Coalfield. He describes these as consisting of from 15 to 20 feet of white micaceous sandstones, alternating with bands of green marl, and further states that they occur at about 250 feet from the top of the Red Marls and 350 feet from their base. About 29 feet of very hard thin micaceous and calcareous sandstones, corresponding to this description, were passed through in the Stratford-on-Avon boring between 290 and 319 feet from the base of the Upper Keuper, which is remarkably close to the position assigned to the the Upper Keuper Sandstone by Mr. Howell. The few fragments which were brought up by the boring tools were searched for *Estheria minuta* but without success.

Whether this 29 feet of Upper Keuper Sandstones is anything more than of local significance is uncertain, but there can be no doubt of the striking lithological similarity of the beds to certain thin sandstones of the Upper Keuper in Worcestershire, Staffordshire, and Nottinghamshire, and it is quite possible that when we have a complete re-survey of the Trias some of the beds of these various districts may be correlated. If this turns out to be the case we shall have, what is now sadly wanted by workers in the Trias, some definite horizons in the Upper Keuper to which observations can be referred with certainty.

The results of the Stratford boring have an important bearing on the question of the thinning out of the secondary rocks against the palæozoic east and west ridge which we have reason to believe underlies the secondary rocks of the southern counties. As far back as 1859 it was pointed out by Professor Hull, in a memoir on the South-Easterly Attenuation of the Lower Secondary formations of England (Jour. Geol. Soc. xvi, 68), that the direction of maximum attenuation of the Triassic rocks is along a line drawn S.E. from the estuary of the Dee, and passing near Nantwich, Stafford, and Warwick. In his subsequent Survey Memoir on the Triassic and

Permian rocks of the Midland Counties, 1869, he gives the following estimate of the thickness of the Keuper along this line:—

	Lancashire and W. Cheshire.	Staffordshire.	Leicestershire and Warwickshire.
Upper Keuper Marls ...	3,000 ft.	800 ft.	700 ft.
Lower Keuper Sandstone ...	450 ft.	200 ft.	150 ft.

Mr. H. H. Howell determined the thickness of the Upper Keuper Marls east of Coventry and Warwick by measuring them across the outcrop from their junction with the underlying Lower Keuper to the overlying Rhætic. He estimated the vertical thickness at 600 feet, and this estimate is strikingly confirmed by the results both of the Rugby and the Stratford-on-Avon borings. The Rugby boring was made in 1861, and, on reaching the Lower Keuper Sandstones at 1,140 feet, was abandoned on account of the highly saline properties of the water (see Rugby School Nat. Hist. Soc. Rep. 1868, p. 41). The Upper Keuper Marls were reached at 480 feet from the surface, and were found to be 663 feet in thickness.

Now, a line joining Rugby with Stratford-on-Avon intersects Professor Hull's South-Easterly line of maximum attenuation almost exactly at right-angles, and we should consequently expect the thickness of the Upper Keuper along this Rugby-Stratford line to be practically the same. Whilst at Rugby the thickness is 663 feet, at Stratford-on-Avon the new boring has proved the Upper Keuper to be 604 feet as a minimum. When to this we add the few feet representing the very uppermost portions of the Keuper Marls, which are not represented in the boring, and which probably amount to from 25 to 30 feet, we find a very remarkable agreement between the Rugby and Stratford data.

South of Stratford-on-Avon the Trias has been reached at two places by boring. At Mickleton in Gloucestershire, eight miles due S. the Upper Keuper was struck at 1,285 feet, and penetrated for 57 feet, when the boring was abandoned.

At Burford, Witney, 26 miles S. of Stratford, the Trias was reached at 821 feet from the surface, and red beds to a total thickness of 428 feet were passed through before the Coal-measures were entered. The available descriptions of these Marls, Sandstones, and Conglomerates, are unfortunately so vague that it is impossible with any degree of certainty to differentiate the subdivisions of the Trias, or to determine whether any portion of the rocks belong, as in all probability they do, to the Permian. The best information I have been able to obtain is derived from a paper by Mr. De Rance, Trans. of Manchester Geol. Soc., vol. xiv (1877-8), p. 438. If the cores of this boring, which was put down by the Diamond Rock Boring Company, are still in existence, it is highly desirable that the portion between the Rhætic and the Coal-measures should be subjected to a close examination by some geologist well acquainted with the Trias and Permian of the Midland Counties.

Mr. De Rance, from the particulars given to him, estimates the New Red Marls to be represented by 291 feet of the cores. Assuming this to be correct we can now estimate the rate of

attenuation of these beds between Stratford and Burford, places lying 26 miles apart, on a line running due N. and S. As we have seen that the maximum attenuation takes place along a line running N.W. and S.E., by drawing a line at right angles to this (*i.e.*, N.E. and S.W.) through Stratford, and letting fall a perpendicular from a point represented by Burford, we find the length of this perpendicular to be about 22 miles, which represents the distance through which the Upper Keuper Marls have thinned out from about 640 feet to 291 feet. This gives about 16 feet per mile as the true rate of attenuation between Stratford-on-Avon and Burford. Mr. De Rance, by the use of Professor Hull's data, arrives at the conclusion that between the Liverpool district and Warwick the Upper Keuper thins out at an average rate of 23 feet per mile, a rate which we see is not maintained as we get further south.

The Stratford boring unfortunately does not give us the thickness of the Lower Keuper, but as this subdivision of the Trias was penetrated to a depth of exactly 200 feet and still maintained the same characters, I think it probable that it is at least 300 feet thick and perhaps more. It is at any rate of greater thickness than the Lower Keuper of Warwickshire, where according to Professor Hull it is represented only by 150 feet of rocks. This discrepancy is probably due to the local thinning out of the coarser sediment against the older rocks of the Warwickshire Coalfield. We have a good example of such a local attenuation of the Trias on the north-west side of the Leicestershire and South Derbyshire Coalfield just East of Burton-on-Trent, where the Keuper thins out against the Carboniferous Rocks, which here formed an old coast line in early Triassic times.

III.—The Destruction and Shattering of the Chalk of Eastern England.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

A SHORT time ago I read a paper before the Geological Society, of which an abstract appeared in the Proceedings, in which I discussed some questions of critical interest in the geology of East Anglia.

I am more than pleased to find that some of the conclusions I pressed, and which I had long ago reached, have been discussed by two such excellent geologists as Professor G. A. Cole and the Rev. E. Hill, whose papers were printed in the December Number of this Magazine (pp. 553 and 555).

That the Chalk of Eastern England was originally laid down in horizontal beds no one will, I presume, deny. That since it was so laid down it has been folded and bent into vast curves, no one who has studied either the surface contours or the well-borings will venture to question. That this folding of the Chalk into a series of wolds with intervening valleys must necessarily, unless the Chalk could slip over its lower beds, have been accompanied

by enormous fractures and by the breaking up of large portions of it into fragments, is as clear as any mechanical problem can be.

When we turn from this *à priori* reasoning to the actual facts we can hardly doubt that the Chalk of Yorkshire, of Lincolnshire, and of East Anglia, which now exists in a disconnected and discrete form in these three areas, was once continuous, and that the vast mass of chalk rubble which exists in the chalky clay of the Eastern and Central Counties of England, is the result of the violent disintegration and dislocation of the beds once occupying large areas now denuded of their chalky covering, and notably of the depression in the Fenland. This dislocation and disintegration I hold to have been coincident with the spread of the chalky clay, and to have occurred, not in the older Tertiary times, but to have been the very last chapter of East Anglian geology.

Let me first partially clothe my heretic self in the garments of some orthodox men. Professor Seeley argues that before the Drift began a Cretaceous barrier dammed out the sea from the Fenland, extending from Hunstanton, in Norfolk, to Wainfleet, in Lincolnshire; and he further argues that before the Drift began this barrier was not broken through (GEOL. MAG., Vol. III, pp. 1–3). Mr. Skertchly agrees in this, and says that before the Glacial age the site of the Fenland basin was very different from its present condition. The Chalk and other Cretaceous and Neocomian rocks stretched from Hunstanton to Lincolnshire, across what is now the mouth of the Wash (Geology of the Fenland, p. 217).

While the orthodox geologists are quite willing to allow this considerable denudation in comparatively recent times of the Chalk country of Eastern England, they mostly attribute it to the effects of either marine or fluvial denudation, or to the action of ice, and do not correlate it with the general alteration of the contour of the country by which the North-and-South-Chalk Wolds of Eastern England were formed.

The following sentence in a paper by Mr. Horace Woodward condenses the current view of the Uniformitarians on this point. "Mention," he says, "has previously been made of the connection of the Norfolk Chalk with that of Lincolnshire. In Miocene and Pliocene times, rivers may have commenced to erode their courses in it, making outlets to the sea. These actions (to quote Mr. Skertchly) resulted in reducing the barrier to outliers; one between the Witham and the three united rivers (Welland, Nene, and Ouse), the other between that united stream and the Little Ouse. As submergence went on, the sea added its powers to that of the rivers, and finally the Chalk disappeared entirely. The sea was now brought directly in contact with the widespread outcrops of the yielding Kimmeridge and Oxford Clays, and the denudation of the Fenland basin proceeded at a rapid pace." ("The Scenery of Norfolk": Trans. Norfolk Nat. Soc., iii, 445.)

Mr. Skertchly and others merely treat the chalk lumps as the débris of marine denudation.

It seems to me that whatever theory is adopted to account for

the chalky clay itself and *its distribution*, it is impossible to attribute the disintegration of the chalky and oolitic débris which it contains to any such diurnal causes as are above mentioned. This chalky débris is nearly all angular or subangular, and absolutely different in kind to any marine shingle or river gravel in the world; and those who have handled, as I have done, many thousands of the lumps of the chalk (it is utterly wrong to call them boulders), with their angular edges and their contour like broken road-metal, cannot, it seems to me, without absolutely forsaking all inductive methods, see in them the débris of marine or fluviatile denudation.

Not only is the angular form of the pieces of chalk incompatible with a fluviatile origin, but the great masses of shifted chalk and oolite, to which I shall presently refer, are still more so; while as to the sea, not only do these same arguments apply, but we have no trace in the Fen country, or in the valley of Axholme and its borders, of the continued presence of the sea there consistent with slow marine diurnal denudation—no old sea margins or shingle beds, no rounded pebbles, except Tertiary ones, and no marine débris of the kind we should certainly find, while the whole of the deposits are entirely different to those of an advancing or retreating sea.

Other people have in these latter years attributed the breaking up of the Chalk to the action of ice, either to land-ice or icebergs or coast-ice. Mr. Jukes-Browne, Mr. Hill, and others have spoken strongly and well on the subject of land-ice, and shown how impossible it is to credit this stupendous denudation to ice in this form. In addition to what they say, we nowhere find glaciers breaking up their beds in this way, not even in Greenland or Alaska, nor is it credible that they should do so if the mechanics of the problem are for a moment considered.

The Chalk-stones, again, are quite different to ice-stones of all kinds known to me, and the occasional scratches on the pieces of chalk, which is a very soft substance, would be certainly caused by any movement in which one stone rubbed against another.

Again, as to icebergs, it is forgotten that it is only when grounded dynamically that they act in the way suggested. When they are floating they are buoyed up by the water, and their pounding action must be very slight. The intervention of coast-ice has been called in by Mr. Mellard Reade to account for the long chalk masses in the contorted drift at Cromer, but he overlooks the fact that similar shifted masses occur in Rutland and Lincolnshire formed of the local rocks there, where no old sea cliffs can be postulated.

Lastly, the suggestion that rocks might under the influence of alternate frost and thaw break up into such rubble as this, is again completely contrary to all experience of Chalk known to me (except on exposed cliffs, and even here very slightly indeed, as we can see by walking along any of the great escarpments which bound that deposit), nor can I see how the mechanical process could begin or go on in a substance with the structure of chalk. Besides, why should the frost have broken up the chalk in the low Fens

and left it intact in the wolds, where it would be so much more exposed to its influence. The position is not arguable.

These various facts and arguments seem to me to converge upon one conclusion, namely, that the denudation of the Chalk and other beds in Eastern England was not and could not be the result of diurnal causes. Let us now try and examine the notion that the ruin of the Chalk was the result of the breakage and disintegration of the strata which occurred when the present contour was given to the country.

First, let us turn from the chalky rubble to the well-known gigantic masses of chalk and oolite which occur occasionally in the Eastern Counties, and to which I have referred. These have always been a crux to the advocates of diurnal methods of denudation. Rivers or sea-waves can hardly move about twenty square miles of Chalk *en bloc* over leagues and leagues of country, and those who believe that land-ice or glaciers could do this, must have some special acquaintance with the inner workings of ice which has not been given to those who have seen it at work in its own special home. To me, who am only a heretic, these great masses now found detached and isolated are not far-transported boulders at all, but are virtually *in sitû*, the remains and relics of the once continuous strata which occupied the areas now largely denuded. If they have been moved, it has been a very short distance and by some tremendous motive force which may have temporarily lifted them and underlaid their edges with chalky clay, but otherwise they are at home where they were originally made and deposited, and are no vagabonds and wanderers. This conclusion I have long held, and it seems to me more consonant with probability than any other. As the matter is of more than usual importance I should like to enlarge a little upon it.

Writing in description of the Geological Survey Map, Sheet 64 (Rutland, etc.), Mr. Judd says: "The transported masses of local rocks are sometimes of enormous size, especially in the northern portion of this area and in that to the south. The attention of geologists was first directed to these great transported masses by Professor Morris, who found that at the south end of the Stoke tunnel on the Great Northern Railway an enormous mass of the *Lincolnshire Oolite limestone* lay on undoubted Boulder-clay. During the mapping by Messrs. Holloway, Skertchly, and myself, of the districts which I have indicated, we have found a number of such transported masses, some of them far exceeding in size that described by Professor Morris, and composed both of the Inferior Oolite and the Marlstone rock-bed. Their position is indicated upon the Drift map. They always appear to occur in the lower part of the Boulder-clay, and by the denudation of the softer surrounding material often make a distinct boss, rising above the general surface. Stone pits are often opened in them, and they sometimes give off springs at their base. The longest of these transported masses, that capping Beacon-hill in Sheet 70, is more than 200 yards across, and is composed of the Marlstone rock-bed. It is noteworthy that these masses always belong to the rocks which form the highest ground." (Geology of Rutland, etc., p. 246.)

When we turn to Professor Morris' paper on one of these famous boulders, it is interesting to see him suggesting that it was not a far-transported boulder, but *in sitû*, or virtually *in sitû*.

Professor Morris, speaking of these beds in Lincolnshire as long ago as 1853, says of the famous Ponton cutting: "The oolites are frequently dislocated, the dislocated portions lying at high angles, and are very irregular. . . . Emerging from the south end of the tunnel [at Great Ponton] . . . . *we see the drift on either side of the cutting buoying up an enormous irregular mass of oolitic rock* through which the cutting has passed. This mass of rock is 430 feet long, and at its deepest part 30 feet thick; it is much broken and disturbed, but the parts retain to some extent their relative position, and belong to the lower portion of the oolitic beds of this district. . . . . The depth of the underlying drift exposed at the lowest part between the broken rock and the level of the railroad is about seven feet. . . . . *this great mass of disturbed oolite, which, although so distinctly isolated, retains sufficient uniformity of character to lead us to infer that it has not been far removed from its original site.*" (Q.J.G.S., vol. lx, pp. 318–320.)

These great masses of shifted rock, of course, occur elsewhere. The typical instances are those in the Norfolk cliffs—that in the Roslyn hole near Ely, the great Merton boulder in West Norfolk, and, more remarkable than all, the great mass of chalk, twenty miles square, recently found by Mr. Cameron on the borders of Huntingdonshire and Bedfordshire. These, and such as these, seem to me to be instances, not of vast transportation, but rather the remains of once continuous strata, and closely allied to the actual outliers found in the county of Cambridge, west of the escarpment of the chalk, and to testify to the once continuous Chalk having been dislocated *in sitû* by some far-reaching subterranean force.

Let us now turn to the evidence that the Chalk has been so dislocated and broken in comparatively recent times.

In many places in Norfolk there have been found, as is well known, evidences, not only of chalk quite disturbed and disintegrated, and reduced to a rubbly condition, but also instances of its being curved and tossed up on end. These disturbances, in the view of some of the best observers, like Mr. Horace B. Woodward, Mr. J. E. Taylor, Mr. C. Reid, Mr. Jukes-Browne, etc., belong to the same date, and were caused by the same forces that made the Boulder-clay. As the matter is one of considerable importance to the argument, I propose to quote some of these cases as described in the Survey Memoirs and elsewhere.

In the Geological Magazine for 1865, Mr. J. E. Taylor described a saddle-shaped anticlinal or ridge in the Chalk at Whittingham. The beds, with conspicuous bands of flints, were so bent as to form an acute angle, which was very well defined. The layers of flint were not shattered, nor were the strata broken. At first Mr. Taylor attributed this disturbance in the Chalk to a time before the deposition of the Norwich Crag, but he subsequently (*id.* vol. vi) attributed the twisting and dragging up of the Chalk to the agent

which formed the Upper or chalky Boulder-clay, a view in which Mr. Horace B. Woodward concurs (*id.* Dec. II, Vol. VIII, p. 93).

In 1866 Mr. Taylor called attention to a similar disturbance in a pit at Swainsthorpe. He tells us that on the left side of the pit the flint bands were nearly perpendicular, being somewhat contorted and leaning towards the right. On the right side the bands were somewhat more perpendicular, but still leaned towards the north. The contorted bands forming an anticlinal arch, the summit of which had been denuded. . . . . flint bands were shattered and broken as though by the influence of some sudden force. (GEOL. MAG., Vol. III, p. 44.)

A similar disturbance occurs in the Chalk at Trowse, and was first pointed out by Mr. T. G. Bayfield. In this pit the Chalk, with layers of flints and paramoudras *in situ*, was inclined at an angle of from 35° to 40° in a south-easterly direction. Mr. Woodward found the bedded chalk pass into sandy and marly beds, and itself contained fractured flints with pebbles of flint and quartzite, which were dispersed throughout it. The flint layers gradually assumed a horizontal position in going downward. He adds—"From the fact that beds of the age of the Norwich Crag are disturbed together with the Chalk, it may be concluded that they were forced up in post-Pliocene times; and from the relations borne by the chalky Boulder-clay to the chalk in this immediate neighbourhood and in many pits round Norwich, I feel no hesitation in concluding that the disturbance was produced by the agent which formed this Boulder-clay." Similar disturbances have been reported by Mr. Wood at Litcham.

Mr. Woodward elsewhere describes a pit showing much disturbed chalk near Burham Abbey, chips of flint and flint nodules occurring in the mass of the rock, the disturbance reaching to a depth of ten feet. At West Rainham the Chalk shows signs of disturbance in an anticlinal arrangement of the flint layers, the fold trending east and west. (Geology of Fakenham, etc.)

Turning to the very important section at Trimingham, I feel constrained to quote Mr. Clement Reid's excellent description. "North-west of Mundesley," he says, "the beds (contorted series) undulate a good deal, the disturbance gradually extending into the lower deposits and becoming more violent, till at last at Gimingham and Trimingham it affects the solid chalk. . . . . The normal position of the Chalk would be below low-water mark; but it has been thrown into a series of undulations which have the effect of raising it above the sea-level. . . . These undulations form definite anticlinal and synclinal folds, having their axes parallel with the coast-line, though minor flexures often obscure the structure where only a small exposure can be seen. The bending has been so violent as to squeeze up a ridge of chalk; of which, judging from the dips on the foreshore, the two chalk bluffs seen in the cliff seem to be the last remnants." Mr. Reid adds—"That this contortion is of Pleistocene age is proved by the similar disturbance of the overlying beds, and by the intrusion of tongues of Boulder-clay into the Chalk." This view confirms that of Lyell, who, as Mr. Reid says, "was fully

aware of this conformity, and gave illustrations of it, mentioned the mixture of Chalk and Boulder-clay on the foreshore, and considered that the contortion must clearly have been formed subsequently to the deposition of the Drift" (Geology of Cromer, etc., p. 95). Again, the same author says: "The Boulder-clay under the folded Chalk is certainly connected with the contortion, as is also the case with the alternations and intrusive tongues of Boulder-clay seen on the foreshore. . . . . The contortion of the Chalk appears to have forced it into the overlying beds and compelled the boulder-clay to mould itself to all hollows and open fissures; it has even in some places caused the Drift to underlie in mass the inverted anticlinal of the solid chalk."

With these facts before us, it seems impossible to doubt the conclusions of Mr. H. B. Woodward and Mr. C. Reid, as related by them in the following words. The former says: "I have come to the conclusion that many of the contortions seen in the strata, whether Chalk, Crag or Lower Glacial, are chiefly due to the agent that brought the Boulder-clay; of the numerous cases where this positive evidence is wanting I know of no instance where the contortion might not have been produced at this period" (Geol. of Norwich, p. 137). The latter says: "The general structure of Norfolk and Suffolk appears to show that the whole of the contortions are of one age, that of the greatest glaciation, or of the great chalky Boulder-clay, and it is probably to this period that the disturbances on the coast may be referred" (Geol. of Cromer, p. 117).

While this conclusion seems inevitable, I cannot concede, even as a possibility, that these contortions have been caused by ice in any form. These contortions are, in fact, only subsidiary folds in the much larger folds which formed the plateau of East Anglia and the adjoining troughs on either hand, and seem unmistakably due to the operation of forces acting from below, or by earth-waves passing laterally through the strata as waves pass through the sea.

The only reason given by the opponents of these subterranean causes is, that the surface layers are alone contorted and puckered, while the deeper ones are not. It is forgotten that this very fact is most difficult, if not impossible, to explain by an ice theory, while, if the contortions are eventually due to the crumpling up of the strata, it will certainly follow that the highest layers will be under the greatest tension; but I have a notion that these folds are really the result of gigantic earth-waves, caused by some tremendous strain; and it will be remembered that in marine waves it is only the surface layers that are affected at all; at a very little below the surface the water is quiescent and still.

If we conclude that the disintegration of the Chalk was the result of subterranean movements, the next question is, When did this occur?

It seems to me impossible to carry back the breaking up of the Chalk strata to Tertiary times. If it had been in progress then in anything at all like the way in which we must postulate it to have occurred, if we are to judge by the lumps of chalk in the

chalky clay, we should certainly find some of these angular and subangular pieces of chalk, some of these great masses of shifted Oolitic and Cretaceous rock, in the sands and gravels of the Crag; but nothing of the kind occurs in them, or in the so-called Chillesford and Westleton Beds. But this is incredible, if the Chalk had already begun to be broken up into this rubble. They come upon us suddenly in the beds above the Crag, and were doubtless the product of the same forces which contorted and faulted and broke the Chalk in so many places, as I have shown. I cannot see how we separate these dislocations from the forces which moulded the surface of East Anglia into its present contour of wold and dale. On this subject we are not entirely wanting in evidence: thus, it is hardly possible to conclude otherwise than that the present depression in the area occupied by the Fens, or the valleys of the Axholme and the Trent, did not exist when these beds were being laid down in the Crag areas, or else we should have had them developed in these hollow troughs more conspicuously than further east. The way in which the later Crag beds themselves occur at high levels above the sea, as at Norwich, and in other inland parts of East Anglia far above the present sea-level, unmistakably points again to the contour of the country having greatly altered since these submarine beds, the very latest so-called pre-Glacial beds, were laid down.

Again, if we travel northward, the position of the Crag beds in reference to the Forest bed points in the same direction. The Middle and Lower Crag, whatever their actual horizon, can hardly be placed above the Forest bed, yet we find in many parts of Suffolk these marine deposits at a considerable elevation above the sea-level, while the Forest bed itself occupies the strand actually below low-water mark. This assuredly points to a considerable dislocation since these beds were laid down. Again, there is another remarkable piece of evidence which has been overlooked —that presented by the well-borings at Boston in Lincolnshire, and at Yarmouth and elsewhere on the Norfolk coast—namely, that the great flexures of the Chalk which have rent it down there to a depth of several hundred feet, were clearly made at this time, since the hollows have been filled up with vast deposits of so-called glacial sands, etc., and with nothing else, showing that these synclinal hollows are among the very latest of geological phenomena.

As I have argued, its effect was to fold the Chalk into a series of anticlinal and synclinal curves, running more or less north and south, and marked by the wolds of Yorkshire and Lincolnshire and the plateau of East Anglia on the one hand, and the hollows of the Axholme valley of the Fens and that forming the southern part of the North Sea on the other.

Now this last hollow was clearly cut out and shaped since the Weald denudation. The denuded Weald area was originally lenticular in shape, like similar denuded surfaces in Western England and the Chalk districts of France. The eastern terminal apex of the original denuded area is still to be found on the other side of the Channel. It was athwart this formerly continuous

valley of denudation that the great synclinal hollow of the North Sea was shaped or cut: a glance at the map will make this quite clear. And this was cut when the connection of England with the Continent was severed, that is, as I have argued in many places, when the Mammoth and its companions were destroyed and the Drift distributed.

This shows that the bending and moulding of the beds of Chalk in Eastern England into their present contours were comparatively recent events in its geological history, and coincident with the break up and disintegration of the Chalk beds. If this subsidence and bending had been slow and gradual, we should hardly have had the tremendous breakage and ruin of which the evidence is everywhere most plain. This shows that the breakage was rapid and cataclysmic, and the result of some great strain suddenly applied—such a strain as occurred frequently enough in the earlier ages of the world, as the interior skeletons of all our mountain ranges show, whenever we examine their crumpled, torn, and dislocated beds, often standing on end. It is strange that the moderate Uniformitarians should allow this in the older times, but be loth to admit it so late as Pleistocene times.

The conclusions I have here formulated were foreshadowed long ago by at least one writer. The Rev. W. B. Clarke, who wrote so well on Suffolk geology, says in the Geological Transactions for 1837: "While the Crag still lay under the sea, a violent catastrophe broke up many of the Secondary rocks, from the Chalk to the Lias inclusive. . . . . After this period, and probably in prolongation of the first great catastrophe, a series of shocks, acting from below, shattered the surface, and gradually elevated the whole district, including the Chalk, till the Crag obtained the height of nearly 100 feet above the sea-level; and by this movement were produced the valleys or lines of fissure through which the drainage of the country is effected." (*Op. cit.* second series, v, pp. 367, 368).

IV.—Post-Pliocene Submergence of the Isle of Wight.

By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S.

I AM tempted to offer a few notes with the conclusions I arrived at during some weeks residence this summer in the Isle of Wight, having been struck with the remarkably definite data which the island affords regarding the maximum depth of the submergence (or height of emergence) during the post-Pliocene period. The "plateau-gravels," which are the main factors in the determination of the amount of submergence, have now been mapped by the Geological Survey,[1] together with the other post-Tertiary deposits; but as regards their mode of formation the Survey (I believe) in its collective capacity refrains from expressing an opinion.[2] I, for my part, have no hesitation in bespeaking for them a marine origin—(1) because of their wide distribution; (2) because of their elevated

[1] Drift-Maps; Sheets 330, 331, 344, and 345.

[2] As stated by Mr. Whitaker in the discussion on Prof. Prestwich's paper on the "Westleton Beds," Q.J.G.S. 1890–91.

position, as shown by Mr. Codrington,[1] Prof. Prestwich, and other writers, which is far beyond the reach of the rivers past or present; (3) because of their stratified structure and their composition. There remain the two other hypotheses, both equally out of the question—that they are lake deposits, or that they are of glacial origin. The absence of shells in the higher levels, reaching to 300–500 feet, is easily explained, and is no argument against marine conditions of deposition, as the percolation of subærial waters through such open and porous beds must necessarily have dissolved away the material of which marine organisms are mainly formed. As regards the geological age of the plateau-gravels of the Isle of Wight and Dorset, there can be little doubt that they are post-Tertiary, as they are found resting indiscriminately on all Tertiary strata of those parts.[2] Prof. Prestwich classes them under the head of "Southern Drift," and distinguishes them from his "Westleton Beds" on the ground mainly of difference in the composition of their constituent pebbles, and their separation from the Westleton Beds of the East of England and the Thames Basin by a barrier along the Wealden ridge. But even admitting this separation, the beds may be representative as regards age; and as for the absence or presence of certain pebbles (such as white quartz, etc), it can scarcely be expected that in any beds of conglomerate of wide extension there should be no variation in the composition of the constituent pebbles. Perhaps, on reconsideration, Prof. Prestwich might be inclined to admit that the plateau-gravel of the south and the Westleton gravel of the centre and east may be contemporaneous. With these preliminary observations, I proceed to the evidence of submergence and emergence afforded by these beds in the Isle of Wight.

As ably shown by Mr. Codrington, the plateau-gravel of the Isle of Wight originally formed a surface sloping from the south northwards towards the shore of the Solent. Subsequent denudation has largely modified the original range of this plateau; wide valleys, such as that of the River Medina, have been channelled through it, and in many places only outliers have been left, of which the most important is that of Headon Hill.[3] In a word, enormous changes in the physical features of the island have occurred since this widespread sea-bed was laid down, which were brought about during emergence in the first place, and afterwards by subærial agencies down to the present day.

Of the numerous disconnected patches of the plateau-gravel, I shall only refer specially to two—that of St. George's Down, south of Newport, and Headon Hill, overlooking Alum Bay at the western extremity of the isle.

St. George's Down.—This terrace is situated in the very centre of the isle, a little to the south of the Chalk ridge. Its upper surface

[1] Quart. Journ. Geol. Soc., vol. xxvi, 1870.

[2] Unless it should be assumed that they are of Pliocene age, of which there is no evidence or probability.

[3] The outlying patches of the plateau-gravel are shown on the new Drift maps of the Geological Survey above referred to.

is almost perfectly level, and it breaks off in a well-marked scarp overlooking the valley of the Medina at a level of (about) 350 feet above the stream; the upper surface of the plateau is about 403 feet above O.D.[1] The terrace is formed of rudely stratified beds of gravel and lenticular bands of yellow sand and loam; current lamination being slightly apparent in some places; the whole resting on the Lower Greensand. The pebbles, which are generally well rounded and waterworn, consist mainly of flint; but there are a few of grit, ironstone, and detritus of Lower Greensand. The whole deposit is about 50 feet thick, of which about half the thickness is laid open to view in the large gravel-pit above Blackwater station. On reaching the surface of the plateau one perceives, at a distance of half a mile, the rounded ridge of the Chalk rising slightly above it, and we easily recognize that we are walking on the floor of the old sea-bed which terminated against the uprising ridge of the Chalk, from which the materials were largely derived.

Headon Hill.—This remarkable outlier is described by Mr. Bristow[2] and other authors; and its relations to the terrace of St. George's Down can scarcely be mistaken. In composition, in altitude, and in its relations to the Chalk ridge, the conditions are almost identical, except that Headon lies to the north of the ridge, St. George's Down to the south of it. The distance between the two is about 17 miles, and the gravel-beds of Headon rest on the Upper Tertiary strata of the Isle of Wight series. Like the St. George's beds, the Chalk ridge formed the limit in one direction to the range of the gravel-bed; towards the north and west it breaks off in the well-known cliff of Alum Bay. The height of the summit is (according to Bristow) 370 feet; my aneroid measurement makes the height 388 feet; in either case the level approximates to that of St. George's Down; and the important point remains to be noticed, that once we reach the 400 feet level, and ascend the ridge of the Chalk downs, these beds of stratified gravel cease, and are replaced by local flint-gravel derived from the underlying Chalk, and left behind after the calcareous matter had been dissolved away by subærial agencies.[3]

It is unnecessary to go into further details in order to show that after the upheaval and denudation of the Tertiary beds of the Isle of Wight the district was submerged, beds of sand and gravel, derived mainly from the waste of the Cretaceous rocks, were laid down, and the whole were subsequently elevated to an extent of about 400 feet, as indicated by the levels of Headon Hill and St. George's Down. The relations of the gravel-beds to the older rocks enable us to fix definitely the amount of this elevation; and this is the point to which I wish particularly to call attention to in this short communication.

[1] By aneroid measurement. The gravel of St. George's Down has been described by Mr. Codrington.

[2] "Geol. of the Isle of Wight": Mem. Geol. Survey (1862), p. 104.

[3] The two varieties of gravel are very well shown on the Survey map already referred to.

V.—Note on the Affinities of the English Wealden Fish-Fauna.

By Arthur Smith Woodward, F.L.S., F.G.S.,
Of the British Museum (Natural History).

THE question of the affinities of the Wealden Vertebrate Fauna having been re-opened by Professor Marsh in his paper on the Dinosauria, read before the last meeting of the British Association at Ipswich,[1] it may be of interest to place on record a complete list of the species of fishes now known from the English Wealden deposits. This is more extensive than any previous list, being based on the unique collection in the British Museum, which has only lately been examined in detail. Unfortunately, however, none of the specimens, except a few examples of *Lepidotus*, are labelled to indicate the precise horizon from which they were obtained; and scarcely any of the names of localities are very definite. The various species may be enumerated in zoological order as follows:—

Hybodus basanus, Egerton, Quart. Journ. Geol. Soc., vol. i (1845), p. 197, pl. iv; A. S. Woodward, Catal. Foss. Fishes Brit. Mus., pt. i (1889), p. 273, pl. xii, figs. 1–5, and Proc. Yorksh. Geol. and Polyt. Soc., vol. xii (1891), p. 63, pl. i, pl. ii, fig. 1. Coast of Sussex and Isle of Wight.

Hybodus striatulus, Agassiz, Poiss. Foss., vol. iii (1837), p. 44, pl. viii*b*, fig. 1. Tilgate Forest.

Hybodus subcarinatus, Agassiz, *ibid.* p. 46, pl. x, figs. 10–12. Sussex.

Hybodus sp.: miscellaneous teeth, some named *Meristodon paradoxus* by Agassiz, *op. cit.*, vol. iii (1843), p. 286, pl. xxxvi, figs. 53–56, others figured in Catal. Foss. Fishes Brit. Mus., pt. i (1889), pl. xi, figs. 14–16. Tilgate Forest.

Acrodus hirudo, Agassiz, *op. cit.*, vol. iii (1839), p. 148, pl. xxii, fig. 27; A. S. Woodward, *op. cit.*, pt. i (1889), p. 296, pl. xiii, fig. 9. Tilgate Forest, and Telham, near Battle.

Acrodus ornatus, A. S. Woodward, *op. cit.*, pt. i (1889), p. 296, pl. xiii, fig. 10. Brixton, Isle of Wight.

Asteracanthus granulosus, Egerton, Ann. Mag. Nat. Hist. [2], vol. xiii (1854), p. 434, and Figs. and Descript. Brit. Organic Remains, dec. viii. (Mem. Geol. Surv., 1855), No. 1, pl. i. Tilgate Forest.

Lepidotus Mantelli, Agassiz, *op. cit.*, vol. ii (1833–37), pt. i, pp. 9, 262, pl. xxx, figs. 10–15, pl. xxx*a*, figs. 4–6, pl. xxx*b*, fig. 2, pl. xxx*c*, figs. 1–7. Including *Lepidotus Fittoni*, Agassiz (*ibid.*, p. 265, pl. xxx, figs. 4–6, pl. xxx*a*, excl. figs. 4–6, pl. xxx*b*, excl. fig. 2), and *Tetragonolepis mastodonteus*, Agassiz (*ibid.*, p. 216, pl. xxiii*e*, figs. 3, 4). Sussex.

Cœlodus Mantelli (Agassiz), Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl. vol. vi (1856), p. 203; *Pycnodus Mantelli* and *Gyrodus Mantelli*, Agassiz, *op. cit.*, vol. ii, pt. ii, pp. 196, 234, pl. lxix*a*, fig. 18, pl. lxii*a*, figs. 6–14. Sussex.

Caturus sp., A. S. Woodward, *op. cit.*, pt. iii (1895), p. 350. Hastings.

Neorhombolepis valdensis, A. S. Woodward, *ibid.*, p. 356, pl. viii, fig. 5. Hastings.

Belonostomus sp., A. S. Woodward, *ibid.*, p. 439. Isle of Wight.

Oligopleurus vectensis, A. S. Woodward, Proc. Zool. Soc., 1890, p. 346, pl. xxviii, fig. 1. Isle of Wight.

Nine genera of fishes are thus represented in the English Wealden, and all, except *Caturus*, are known by sufficiently characteristic specimens to be determined with certainty.

Of these fishes, the three Elasmobranchs *Hybodus*, *Acrodus*, and *Asteracanthus* are essentially Jurassic. The beautiful examples of the skeleton of *Hybodus basanus* from the Sussex coast prove

[1] Abstract published in Geol. Mag. [4], Vol. III, pp. 1–9 (1896).

that this shark had a persistent notochord and other characters like the typical species of the genus in the Lower Lias of Lyme Regis. They show only one difference from the Liassic type, namely in the cephalic spines; the Wealden specimens not being barbed and never observed in more than one pair. In Cretaceous strata, on the other hand, there is no certain evidence of *Hybodus*. Most of the teeth commonly ascribed to this fish probably belong to another shark (*Synechodus*), which has well-developed vertebral centra and smooth dorsal fin-spines; while the ribbed dorsal fin-spines occasionally found in the English Gault, Cambridge Greensand, and Upper Greensand, may be referable either to *Hybodus* or *Acrodus*. Typical teeth of the latter occur rarely in the Gault of Folkestone, but are not known elsewhere. The tuberculated fin-spines of *Asteracanthus* are scarce in the Wealden, and have never been recorded from a higher horizon, unless a fragment described by Pictet from the Lower Neocomian of Switzerland[1] happens to be of a little later date.

Lepidotus Mantelli is most closely related to the species from the Lithographic Stone of Bavaria. Only few and fragmentary remains of the same genus are known from the Neocomian, and all fragments of later date are very doubtfully placed here. *Caturus* is also typically, if not exclusively, Jurassic; and the abraded skull in the British Museum from the Wealden of Hastings (No. P. 6360) cannot be generically distinguished from that of this fish. *Oligopleurus* is also known only from the Jurassic, occurring in the Lithographic Stone (Lower Kimmeridgian) of Ain, France, and in the Purbeck Beds of Dorsetshire.

Belonostomus ranges throughout the Upper Jurassic and to the Upper Cretaceous, with a very wide geographical distribution; but the only known specimens from the Wealden are too imperfect to determine whether they are most closely related to the earlier or to the later species. *Neorhombolepis*, however, although very rare, is an essentially Cretaceous fish, the typical species occurring in the Lower Chalk of Kent; and it is noteworthy that the most closely related genus, *Otomitla*, is found in the Neocomian of Mexico.[2] The Pycnodont *Cœlodus* is also typically Cretaceous, though represented occasionally in the Purbeck Beds and other formations on the horizon dividing the Jurassic and Cretaceous series.

The result is, therefore, that all the known English Wealden fishes are survivors of typically Jurassic genera, except *Neorhombolepis* and *Cœlodus*, and these are their little-modified representatives. None but *Belonostomus* appear to range throughout the Cretaceous. In fact, the Wealden estuary seems to have been the last refuge of the Jurassic marine fish-fauna in this part of the world, not invaded even by stragglers from the dominant race

[1] *Asteracanthus granulosus* (Agassiz), Pictet and Campiche, "Foss. Terr. Crétacé St. Croix," p. 98, pl. xii, fig. ii (1859).

[2] J. Felix, Palæontogr., vol. xxxvii, p. 189, pl. xxix, fig. iii, pl. xxx, figs. 3-5 (1891).

of higher fishes which characterized all the seas of the Cretaceous period. The Wealden river drained a land where a typically Jurassic flora flourished [1]; the only two known Mammalian teeth from the Wealden resemble those of a Purbeckian genus [2]; and now it is clear that the fishes agree both with these and the reptiles in their alliance with the life of the Jurassic era.

VI.—*Merocrinus Salopiæ*, n.sp., and another Crinoid, from the Middle Ordovician of West Shropshire.

By F. A. Bather, M.A.

In June, 1895, Mr. G. H. Morton, F.G.S., of Liverpool, submitted to me three specimens of Crinoidea, registered No. 681 in his collection. One of these specimens was a stem-fragment, impossible to determine; but the other two appeared of such interest that Mr. Morton very kindly allowed me to make a detailed study of them. The results, though not so complete as might be wished, are now submitted to geologists and zoologists, in order that the former may look out for further specimens, and the latter give us the benefit of their opinion.

Locality.—With regard to all three specimens, Mr. Morton writes, under date 24th July, 1895: "I obtained them 25 or 30 years ago at Mincop, the name of a farmhouse, at the north end of a low hill which ends there, being near the east end of a dyke marked red on the 1-inch map, 60, N.E. (Welshpool), on the S.E. of the map. They were collected in a small quarry, or rather large hole, in a field above the house, just inside the gate of the field. I went there seven years ago, but found the hole filled up and corn growing over the spot, so that there is no chance of obtaining any more specimens there. Mr. Watts told me that he had found the same bed on the strike, but I do not think any fossils."

Horizon.—On page 17 of "The Geology . . . of the Country around Shelve," issued at the end of Proc. Liverpool Geol. Soc., session x, 1869, Mr. Morton thus describes the beds: "In ascending order [the Priest-Weston sandstone] is succeeded by the strata of Mincop and Meadow Town, composed of hard light grey sandstones, interstratified with shales possessing an indurated appearance. These sandstones, which run in beds about six inches thick, contain very good examples of *Strophomena compressa*, *Orthis testudinaria*, *Beyrichia complicata*, *Trinucleus concentricus*, *Calymene brevicapitata*, *Diplograpsus pristis*, *Pyritonema fasciculus*, *Glyptocrinus basalis*, and others. The shales associated with the sandstones in many places contain innumerable trilobite impressions, *Asaphus tyrannus*." The name *Glyptocrinus basalis* in the preceding list refers, Mr. Morton tells me, to all three specimens. The stem-fragment presents some

[1] A. C. Seward, "Catalogue of the Mesozoic Plants, Brit. Mus.—The Wealden Flora, part ii," p. 240 (1895).

[2] A. S. Woodward, "On a Mammalian Tooth from the Wealden Formation of Hastings," Proc. Zool. Soc. 1891 (1892), p. 585; R. Lydekker, "On a Mammalian Incisor from the Wealden of Hastings," Quart. Journ. Geol. Soc., vol. xlix, p. 281 (1893).

resemblance to the stem of *G. basalis*, M'Coy, but not enough to warrant the use of the name. The two other specimens are certainly not *Glyptocrinus*. The rocks just described are part of the "Middleton Group," which is the middle of the Meadow Town Series, which is the middle of the Ordovician (see Prof. C. Lapworth, "Preliminary Note on the Ordovician Rocks of Shropshire," GEOL. MAG., Dec. III, Vol. IV, p. 78, 1887). Older writers call them Llandeilo Beds.

Description.—The two specimens studied are in a dark, fine-grained, micaceous sandstone, and are in the form of moulds, the calcareous substance of the crinoid having been dissolved. They are therefore best studied from wax squeezes.

SPECIMEN A.

The lower, or proximal, part of the Dorsal Cup is wanting. Of the basals (BB) a portion only is preserved. The radials (RR) appear to alternate regularly with the basals, and do not appear to be horizontally bisected. They are about as wide as high, depressed towards the interradial sutures, and projecting slightly in the median line towards the articular facet. The facet occupies the greater part, but not quite all, of the width of a radial, so that the arms clearly are separate from one another; in other words, the crinoid is an Inadunate.

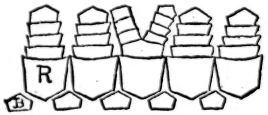
Of the Arms, four are visible. They appear to dichotomize pretty regularly, though the dichotomy is only seen clearly in the second from the left. This, which I take to be the left posterior arm, has brachials as follows: IBr, 5; IIBr, 8–8; IIIBr, 8·10–8·3 (preserved, ends not seen); IVBr, only traces seen. The next arm, *i.e.* the second from the right, appears to be the right posterior arm, since the first primibrach appears to be axillary, and supports a branch on the left, which I take to be the anal tube; of the right branch only three more brachials are preserved: in other words, four primibrachs in all are preserved. The arm on the right of the specimen appears to be the right anterior arm: it is difficult to decide whether the small branches that appear to be given off from its left side may not really be a single branch seen from the inner surface, at least for a distance of six ossicles, after which there are plainly two branches. In all the arms the proximal primibrachs seem rather wider than the distal primibrachs. Each brachial seems to be slightly wider at its distal end, so that the arms tend to have an imbricated appearance.

The Anal Tube (*t* in Fig. a), arising from the left upper slope of IBr_1, is thinner than the arm-branches at corresponding levels, and shows no signs of further dichotomy. Its exposed side shows a longitudinal series of rounded ossicles, of similar appearance to the brachials. The distal end is not seen.

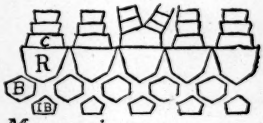
Measurements: total height of specimen, 9·0 mm.; width of cup at level of top of RR, about 1·5 mm.

Systematic position of Specimen A.—The relation of arms to cup shows that this specimen belongs to the Inadunata. The absence of the base does not enable us to refer it to either Monocyclica or

Dicyclica with certainty, though the regularity of the cup is in favour of the latter. A similar disposition of the anal tube is found, among Monocyclica, only in *Iocrinus*; among Dicyclica, only in *Merocrinus*. So far as geological horizon is concerned, the specimen might belong to either of these genera. *Iocrinus* is at present known from the Hudson River Group of Ohio and from the Trenton Limestone of New York. *Merocrinus* has been found only in the Utica Shale of Ohio and in the Trenton Limestone of New York. Neither genus has hitherto been recorded from Europe.



Iocrinus



Merocrinus

Comparing specimen A with *Iocrinus* and *Merocrinus*, we note that the anal tube of *Iocrinus* is composed of numerous hexagonal plates, set along the sides of the mid-rib, as one may call it, that starts from the arm. Specimen A, however, shows no traces of these lateral plates, although it is so preserved as to have done so had such been present; on the contrary, the anal tube appears to have been a simple narrow tube, precisely as in the known species of *Merocrinus*. All known species of *Iocrinus* further resemble one another in the marked imbrication of the brachials; while the species of *Merocrinus* have as a rule smooth brachials, although *M. curtus*, as figured and described by Ulrich ("*Dendrocrinus curtus*," Journ. Cincinnati Soc. Nat. Hist., II, p. 18, pl. vii, fig. 14, 1879), has brachials "prominent at the superior lateral angle." The very slight development of this feature in the Mincop specimen is therefore characteristic of *Merocrinus* rather than of *Iocrinus*. In other respects the specimen might belong to either genus; but the balance of evidence favours its reference to *Merocrinus*.

In minor characters specimen A differs from the known species of both *Iocrinus* and *Merocrinus*. From *Iocrinus crassus* and *I. subcrassus* it is distinguished by its less robust appearance, less wide radials, and less imbrication of the arms, as well as by the above-mentioned character of the anal tube. In a less degree the same characters separate it from *I. trentonensis*, a species which, according to Walcott's figure (Regent's Report, N.Y. State Mus., XXXV, p. 210, pl. xvii, figs. 7 and 8, 1884), further differs in the possession of a slight ridge along the back of the radials and primibrachs.

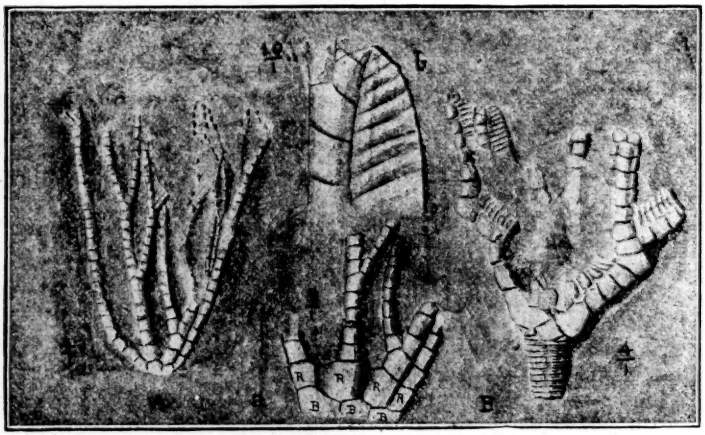
From *Merocrinus curtus* specimen A is clearly distinguished by the regular dichotomy of its arms, for in *M. curtus* there are simple armlets, "about half as stout as the main arm from which they spring." The cup is also lower in *M. curtus*. It was doubtless a mere slip that made Mr. Ulrich describe the anals of this species as rising from the right side of the right posterior arm, instead

of from the left side. *M. typus* is a species of totally different appearance, owing to all its cup-plates and brachials being considerably wider than high. To *M. corroboratus*, the preserved portion of specimen A presents a close resemblance; the basals, however, appear to have been higher in proportion, the arms are a trifle more slender in the proximal region, and their distinct though slight imbrication constitutes an appreciable difference.

Therefore, although Mr. Morton's specimen 681A is imperfect, the preceding facts, combined with the absence of other known representatives of *Merocrinus* on this side of the Atlantic, justify its being taken as the type of a new species, which may be named after the county of its origin, and thus diagnosed:—

Merocrinus Salopiæ, n.sp.

RR and BB as high as wide. Arms slender, bifurcating at intervals of eight or more ossicles. Br wider, or with a slight cornice, at their distal margin.



A. *Merocrinus Salopiæ*, 4 times nat. size. **a**. Lower portion of same specimen, 9 times nat. size.

B. An undetermined Inadunate Crinoid, 4 times nat. size. **b**. Portion of the arm, 10 times nat. size.

The drawings were made from wax squeezes, by Miss G. M. Woodward and the author.

Specimen B.

The plates of the Dorsal Cup are disturbed. A basal and two radials can be distinguished. The radials are comparatively large, and seem irregular in shape.

The relation of the Arms to the cup seems to be that of an Inadunate crinoid. The arms appear to have been regularly dichotomous. That on the right of the drawing has IBr, 4; IIBr, 7 in the left branch, the axillary of which (IIAx) bears one IIIBr on either side. The evidence of the specimen is rather against there

having been any branches beyond IIIBr, or at least beyond IVBr. The branches seem to have diverged at rather a wide angle.

The most remarkable feature of the arms are the structures that seem to spring from the side of the brachials, and somewhat resemble pinnules (see enlarged figure **b**). The only known structures with which they can be compared are either pinnules or covering-plates. But they are not pinnules; for they are more numerous than the brachials, and are not regularly disposed with regard to them. And they are not covering-plates; for in that case the covering-plates would be wider than the arm, which is impossible. In the actual specimen they present the appearance of fluted impressions, the flutings being parallel to one another, and inclined upwards at rather less than a right angle to the arm. About two flutings go to a brachial. It is impossible to tell whether the elements represented by the flutings were separate from one another, or fixed by their adjacent sides. Neither is it certain whether the element represented by each fluting was in one piece, or composed of a series of ossicles, as would be the case with a pinnule. In fine, they are mysterious structures, and I don't understand them.

Of the Stem, the proximal 2 mm. are preserved. It consists of low ossicles, alternating in height, and the higher ones projecting slightly beyond the others. The width where it joins the cup is 1·5 mm., and thence it tapers slightly distalwards.

The crushed state of preservation and imperfection of the specimen prevent one from referring it to any known genus, and still more from founding a new genus for its reception. But the peculiar and novel features that it presents have led me to publish this description.

Wax squeezes of these specimens are preserved in the Geological Department of the British Museum (Nat. Hist.), where any student can see them on application; they are registered E 6484 and E 6485, respectively.

VII.—On the Comrie Earthquake of July 12, 1895, and on the Hade of the Southern Border Fault of the Highlands.

By Charles Davison, M.A., F.G.S.;
Mathematical Master at King Edward's High School, Birmingham.

In Mallet's great "Catalogue of Recorded Earthquakes," the name of Comrie first appears under the date September 2, 1789, and, from that time until the present day, the village has been widely known as a centre of earthquake shocks and sounds. For many years past, however, they have become more and more rare: the shocks, when they have occurred, have been exceedingly slight, and the disturbed areas correspondingly small. Several persons living but a few miles from Comrie inform me that they have never felt a shock; and those who reside in the village itself often speak of "hearing" the earthquakes, as if the vibrations did not generally exceed that limiting degree when they are perceptible only to the ear.

On the 12th of last July, at about 7.40 a.m. (G.M.T.), a slight but undoubted shock was felt at Comrie and for a few miles around. Houses are unfortunately somewhat widely scattered in the district, and it has been difficult to collect as many records as could be desired. I have succeeded in obtaining only 21 observations from 19 different places, and even this number would have been smaller had it not been for the kindly assistance of Mr. T. Boston, of Balmuick, who supplied me with the names of several observers, and also with three or four records of considerable value. In addition to the above places, I have received information from 17 others, where, so far as is known, no trace of the earthquake was perceived. These are of some assistance in drawing the boundary of the disturbed area, though less than is usually the case, either on account of their outlying position or of the small number of inhabitants they contain.[1]

On the accompanying map (Fig. 1), a small disc with a cross through it indicates that the shock was felt and the sound heard, a small circle with a cross that the sound was heard but the shock not felt, a cross that the sound alone was observed, and a circle that no trace of the earthquake was perceived.

The continuous line represents the isoseismal line corresponding to intensity III of the Rossi-Forel scale. The area enclosed by it is $5\frac{1}{2}$ miles long, $4\frac{1}{6}$ miles broad, and contains $18\frac{1}{2}$ square miles. Its centre lies $\frac{1}{4}$ mile south-west of Comrie, or half-way between Ross and Dalginross.

Outside this line the shock was certainly felt at two other places, at Easter Ballindalloch very slightly, and rather more strongly at Westerton. At several other places outside the isoseismal III the sound only was observed. This was the case at Braefordie, Carroglen, Glenturret Lodge, Wester Dundern, and Easter Dundern, but at the last-named place, it should be mentioned, the observer was at work in the open air, and therefore in a most unfavourable position for detecting a weak tremor. Similar observations to the south of the disturbed area are not forthcoming, but it is clear that, to the north and west at any rate, the sound-area overlapped the disturbed area.

[1] Authorities.—Aberuchill, Mr. M. M'Intosh; Ardvorlich, Col. J. Stewart; Auchnafree, Mr. A. Richards; Balmuick, Mr. T. Boston; Bishopsfauld, Mr. T. K. Robertson; Braefordie, Mr. J. Stewart; Carroglen, Mr. T. Boston; Clathick, Capt. W. C. Colquhoun; Comrie, Mr. S. Campbell, Rev. W. Hall, Rev. A. C. Watt; Culty-Craggan, Mrs. Finlayson; Crieff, Mr. G. Straithairn; Dalchruin, Mr. W. Cairns; Dalchonzie, Miss Newbigging; Easter Ballindalloch, Mr. J. Campbell; Easter Dalginross, Mr. D. W. Kemp; Easter Dundern, Mr. P. M'Laren; Fairness, Mr. W. Bell; Foulis, Rev. T. Hardy; Garrichrew, Mr. J. McLaren; Gilmerton, Rev. G. Henderson; Glenample, Mr. T. Walters; Glenturret Lodge, Mr. T. Boston; Innergeldie, Mr. J. Craig; Laggan, Mr. D. Ewing; Lawers, Col. D. R. Williamson; Little Port, Mr. J. Morrison; Locherlour, Mr. S. Campbell; Madderty, Rev. L. C. M. Wedderburn; Ross, Mr. R. M'Laren; St. Fillans, Rev. T. Armstrong: Tyghnablair, Mr. P. M'Intyre; Tomanor, Mr. A. McNaughton; Wester Ballindalloch, Mr. T. Boston; Wester Dundern, Mr. P. M'Ara; Westerton, Mr. D. Keith Murray.—I beg to offer my hearty thanks to the above ladies and gentlemen, and also to Mr. J. Robertson, of Coupar Angus, who kindly sent me early notice of the occurrence of the earthquake.

The shock was an exceedingly slight one. Its intensity was greatest at and near Comrie, but even here it was less than IV, that is to say, it was not strong enough to make doors, windows, etc., generally rattle, though in isolated cases this may have happened. At Comrie it consisted of a slight uninterrupted tremor, lasting two or three seconds, accompanied by a rumbling sound like the passing of a heavy carriage or the discharge of stones from a cart.

The beginning of the sound preceded that of the shock at Dalchonzie, Easter Ballindalloch and Tomanor; coincided with it

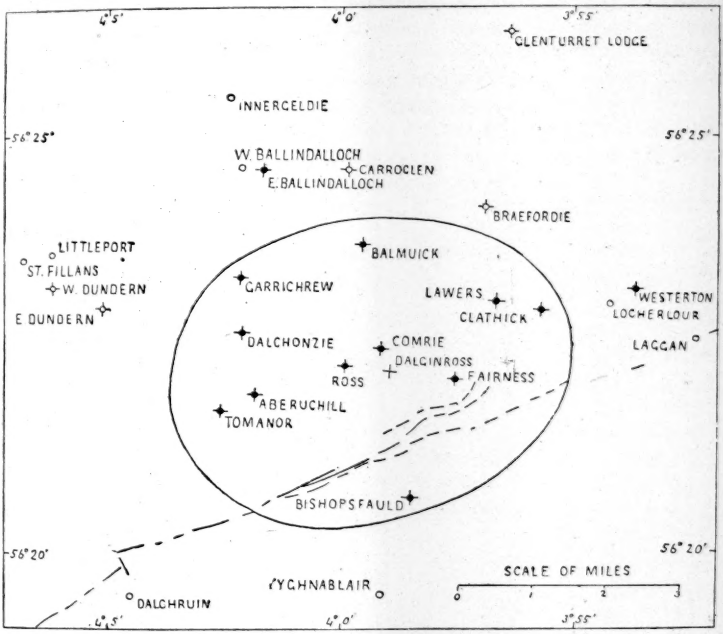


FIG. 1.—Diagram-map of the Comrie Earthquake.

at Comrie and possibly also at Bishopsfauld; and followed it at Ross. The end of the sound preceded that of the shock at Easter Ballindalloch, and followed it at Bishopsfauld and Ross.

The broken line on the map indicates the course of the great southern border fault of the Highlands. It has always been customary to associate the Comrie earthquakes with movements taking place along this fault. The evidence, so far, has perhaps hardly been sufficient to amount to a proof of the supposed connexion, but in the present case the position of the disturbed area and the direction of its longer axis seem to me a strong argument in its favour. In the case of so slight a shock, the phenomena are of the simplest possible character, but, so far as I know, there is nothing inconsistent with the view that the earthquake was caused by a slight slip of one of the system of faults taking place in the immediate neighbourhood of Comrie.

My object in drawing special attention to this shock is not on account of any peculiar interest which it in itself possesses, so much as from the evidence it supplies as to the direction in which the great fault hades. "There is," as Sir Archibald Geikie has kindly informed me, "no sufficient section of the Highland Border fault to show its hade. Normally, of course, it should be to S.E., and perhaps it is so on the whole. But there are traces of great and irregular disturbance along the line, so that the hade may here and there be to N.W." The seismic evidence in the present case of course applies only to the Comrie district, but, if I am right in associating the recent earthquake with a slip of the fault, there can be little doubt I think that the fault near there hades to the north-west, and that it is therefore in this part a reversed fault.

As this conclusion is of some importance from a geological point of view, it may not be out of place to refer briefly to the evidence in its favour.[1]

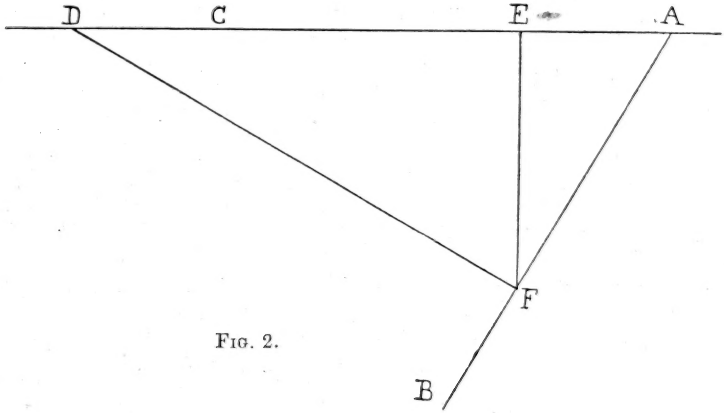


Fig. 2.

If the seismic focus, F (Fig. 2), were a point, the intensity of the shock on the earth's surface AD would be greatest at the point E vertically above it; that is to say, the epicentre would lie on that side of the fault-line towards which the fault AB hades.

But, in the case of earthquakes produced by fault-slipping, the seismic focus is a surface one, and, it may be, of considerable extent both along the strike and the dip of the fault-surface. Supposing for a moment that the intensity of the shock undergoes no diminution as the distance from the focus increases, it is evident that the intensity at any point on the earth's surface will be greater the shorter the duration of the shock. Now, the duration will be least at the point D, where the line perpendicular to the fault-surface through the centre F of the focus meets the earth's surface.[2] But

[1] In a future paper I hope to enter more fully into this question, as well as to summarize the evidence in favour of the fault-slip theory of earthquakes.

[2] The argument may also be stated as follows: The point D is that which is affected simultaneously by the disturbances proceeding from a larger part of the focus than any other point on the earth's surface.

as the intensity does diminish as the distance increases, the maximum intensity will occur at a point C somewhat nearer the fault-line. Thus the centre of the disturbed area should lie on the side of the fault-line towards which the fault hades, and the greater part of the disturbed area should also lie on the same side of the fault-line.

Referring to the map (Fig. 1) it will be seen that by far the greater part of the area disturbed by the earthquake on July 12 lies on the north-west side of the fault-line, leading to the inference that the hade is also in this direction. It is perhaps unnecessary to accumulate evidence on this point, but it may be mentioned that it is at Comrie itself, also on the same side of the fault-line, that the majority of slight shocks and sounds have been in times past observed.

VIII. — Phyllade, Phyllite, and Ottrelite.

By Prof. Grenville A. J. Cole, M.R.I.A., F.G.S.

In his article in the last number of the Geological Magazine[1] Mr. A. R. Hunt points out a number of differences in the use of the terms "schist, slate, phyllite, and foliation." The usage of English-speaking peoples has long ago restricted the word "schist," so that it is no more an equivalent of the French "schiste" and of the German "schiefer" than "mutton" is of "mouton." Prof. Bonney's position is, however, one of exceptional restriction, as he himself has always carefully pointed out. The terms "phyllade" and "phyllite" are surrounded by less controversy. I regard both as unnecessary, seeing that we cannot have names for every gradation from a clay-slate to a mica-schist; but it is fairly clear that the original "phyllades" were slates containing some mica. The term was used in 1813 by Brongniart ("Essai d'une classification des Roches mélangées," p. 35), who ascribes it to the joint authorship of himself, Brochant, and D'Aubuisson. He gives as a synonym, "Thonschiefer mélangé des minéralogistes allemands," and defines the rock as having a ground of clay, with mica, quartz, felspar, amphibole, chiastolite, etc., in it, either together or separately; "structure feuilletée." None of the types which he describes are free from mica. D'Aubuisson de Voisins ("Traité de Géognosie," tome ii, p. 93) in 1819 devoted one of his elaborate disquisitions to Phyllade, giving as synonyms "Thonschiefer; Clay-slate; Ardoise, schiste de Saussure et des anciens minéralogistes; Schiste argileux de M. Brochant." D'Aubuisson objects to the restriction of "schiste" to any one species of rock, and keeps phyllade distinct from those clays which are derived as detritus from pre-existing rocks. He says that the surface of phyllade is sometimes smooth, sometimes deeply striated, as if puckered up ("froncée"); and he shows how the true type of the rock is approached by gradations from mica-schist, until the mica and quartz are so finely divided as be indistinguishable, save for some

[1] Geol. Mag., 1896, p. 31.

flakes of mica and granules of quartz embedded in the apparently homogeneous ground. The justification for using "phyllade" as a term intermediate between mica-schist and common slate is to be found in the passage (p. 97) "Le phyllade passant du schiste-micacé à l'ardoise, par des nuances insensibles et diversifiées sous tous les rapports, le nombre de ses variétés est presque indéfini." D'Aubuisson believed the fissile structure to be parallel to the stratification, and combated the acute views of Voigt, who had observed a strong divergence between the two structures in Thuringia.

Brongniart, in 1827 ("Class. et caract. min. des Roches homogènes et hétérogènes," p. 88), refers "phyllade" to D'Aubuisson only, and states that this rock is "composé essentiellement de Schiste argileux comme base, et de Mica . . . . . c'est le véritable *schiste micacé*." "Schiste argileux" (p. 61) is with him a common clay-slate, and he swallows up "mica-schist" now altogether in "phyllade." This introduces sufficient confusion, when we remember that D'Aubuisson, on the other hand, allied "phyllade" more to the clay-slates than to the mica-schists. Coquand, in 1857 ("Traité des Roches," p. 307), grouped together as "argiloschiste" all the clayey "schistes" of metamorphic origin in which the constituents were very finely grained, and gives the term "phyllade" as a synonym. Our latest glossary (L. Lessing, "Petrographisches Lexicon," 1894, p. 177) gives "Phyllit" as a translation of "Phyllade," due to Naumann, and defines both rocks as micaceous "Thonschiefer." It is clear, then, that these two terms, if required at all, should be used in the sense in which they are already generally accepted. I have shown that D'Aubuisson himself, with a foresight that is not accidental, distinguishes between "phyllades" and detrital rocks; for him, phyllades were allied to granite and not to clays. The minerals in them had arisen *in sitû*, a view which the study of metamorphism has since led us to support. Mr. Hunt's comments on this point seem perfectly correct.

We need not discuss the mineral styled "phyllite" by Thomson in 1828 (Annals of the Lyceum of Nat. Hist., New York, vol. iii, p. 47), but for its bearing on chloritoid and ottrelite. Only the strict respect for priority entertained by the late Prof. J. D. Dana caused the name to be retained as that of a mineral species. Mr. Hunt surely does not find it in "popular" use, and it is given as a mere synonym of ottrelite in the revised edition of Dana's "System of Mineralogy," 1892. But this raises another point that is well worth settling—is oxide of manganese or of magnesium really present in ottrelite and in Thomson's "phyllite"? "Manganese" is not so obvious a clerical error in the description of "phyllite" as Mr. Hunt suggests, since the relation of the mineral to typical ottrelite depends on the presence of this constituent. *Manganese*, not magnesia, is ascribed to "phyllite" in the famous fifth edition of Dana's "System," and in the new edition of 1892. Hintze ("Handbuch der Mineralogie") gives the same figures for *magnesia*. Mr. F. W. Rudler has kindly looked up Thomson's original paper for me, and informs me that Hintze is correct.

J. D. Dana, but for this slip, would probably have classed "phyllite" as a common chloritoid, instead of with the manganiferous ottrelite. Lacroix, in 1886, urged the practical identity of ottrelite and chloritoid, and these names appear as synonyms in Lévy and Lacroix, "Minéraux des Roches," p. 171. Descloizeaux and Damour, however (Ann. des Mines, 1842, tome ii, p. 359) found over 8 per cent. of manganous oxide in the ottrelite of Ottrez, and recorded no magnesia. Hintze, in his "Mineralogie," quotes no analyses of chloritoid with more than 1·30 per cent. of MnO, few containing this oxide at all. Hence I fancy that the name ottrelite will be worth keeping for chloritoids with more than 5 per cent. of manganous oxide and little or no magnesia. This would exclude some substances that have recently been styled ottrelite, and would necessitate a modification in the treatment of that mineral in my "Aids in Practical Geology" (second edition, p. 157), where I have regarded it as synonymous with chloritoid proper and have made no mention of the distinctive manganese.

REVIEWS.

I.—Mining Handbook to the Colony of Western Australia, written especially for Prospectors. By Harry P. Woodward, J.P., F.G.S., F.R.G.S., F.I.Inst., Government Geologist.[1] Second edition. Perth, Western Australia, 1895.

THE value of mining handbooks to the pioneers engaged in opening up the mineral resources of a new country has long been recognized. Much depends on the industry and skill of these men, and all possible help should be given to them, as they do work which would be none too easy to a trained geologist, armed with all the resources afforded by a chemical laboratory and a technical library. Whether it is to be deplored or not, it is certainly true that pioneers have usually more courage and energy than scientific attainments, and a really satisfactory handbook is therefore of paramount importance to them. It must be comprehensive, concise, and easily intelligible to ordinary readers; no technical or scientific knowledge on the part of its readers must be taken for granted, and, on the other hand, useless information must be rigidly excluded. The volume under review is an excellent example of the best type of such books. It is brief, yet clear; full of details, yet interesting; accurate, but not defaced by a multitude of technical terms.

It begins with a slight sketch of the colony, giving some account of the towns, population, climate, water supply, timber, etc. The intending immigrant would perhaps like to hear more about the climate, especially as to the daily and monthly range of temperature in different districts, and would possibly be curious respecting insect life, which is not touched on; but generally the information is wonderfully full and varied. The difficulty as to water supply in the interior is insisted on, and Mr. Woodward points out that the numerous lakes shown on the maps must not be relied on to furnish

[1] See also p. 96 of the present Number Geol. Mag.

any useful supplies. These lakes are usually dry salt wastes, which are occasionally covered by a few inches of water after heavy rains, although even then the water is salt. At Coolgardie the water in the wells is almost a saturated solution, containing 40 ounces of salt to the gallon, as compared with $5\frac{1}{2}$ ounces in a gallon of sea water. Mr. Woodward considers that the best means of obtaining fresh water in the district will be by constructing large dams to save the rain water thrown off the granite hills.

The geology and mineralogy of the country are next dealt with, each section being preceded by a short general account of the science in question. These accounts are in the main excellent, but it may well be doubted if the two pages devoted to chemistry will serve any useful purpose. More than half of them consist of a complete list of the elements, including the rarest, and even some whose existence is doubtful, together with the atomic weights, correct to the second or third decimal place. While useful to the chemist, it is probable that the exact meaning of this table would escape the "practical man." Until recently the geological formations were supposed to consist of either granite or sand, but Mr. Woodward has shown that this is not the case, although the absence of natural sections makes a complete study somewhat difficult. "Speaking roughly," he says, "as a whole, the country may be described as one large table-land, rising to an elevation of from 1000 ft. to 2000 ft. above the sea, and covered for the most part with sandy deposits, which have resulted from the denudation of the Desert Sandstone Series," of Mesozoic age. "Underlying this Desert Sandstone formation there is a series of belts of metamorphic and granitic rocks, the former of which are intersected by numerous diorite dykes and quartz veins, which are proving to be very rich in gold." The auriferous metamorphic rocks are partly Silurian, partly Cambrian, but mainly Archæan. There are six of these belts in all, consisting of highly-contorted rocks striking north and south and having a nearly vertical dip. The fourth and sixth belts, counting from west to east, consist of schists intersected by the gold-bearing veins, whilst the third and fifth consist of barren granite, which long acted as a barrier, discouraging prospectors from pursuing their researches farther into the interior. The disposition of these belts is clearly shown on the capital geological sketch map included in the volume.

In the succeeding pages there is a very useful description of the minerals occurring in the gold-fields, together with directions for identifying them. It may be gathered from the section on metallic gold that Mr. Woodward holds the view that alluvial gold consists of particles derived from the denudation of auriferous lodes, a view which, whether it be correct or not, is not an advantageous one for the prospector to hold, since it often leads to vain searches after lodes where none can exist. Moreover, it would perhaps be better if, instead of the comparatively inefficient iodine test of the presence of traces of gold in rock, the easier and more certain tests by chlorine, bromine or cyanide of mercury were described. But these slight blemishes, if indeed they are blemishes, detract but little from

the value of the mineralogical compendium, one of the most important parts of the book to the prospector.

The greater part of the remainder of the volume is devoted to a detailed account of the various gold-fields, and of the copper, lead, tin, and coal deposits, this account being certainly by far the best which has yet appeared. The description of the coal-fields, on the value of which the development of the colony in no small measure depends, is mainly taken from Mr. Woodward's last annual report, lately noticed in these pages. Three appendices follow, containing those laws and regulations which are of importance to prospectors, some advice as to their outfit and mode of operation, many useful tables, a glossary of scientific and mining terms, and full information on shipping and railway matters. As already stated, the whole book is highly creditable to Mr. Woodward and to the Government Department represented by him. Not a page is wasted, and hardly a page could be added to it with advantage. It need hardly be added that it will be indispensable to every visitor to the colony, to say nothing of the prospectors. T. K. R.

II.—The Fauna of the Bohemian Gas-coal. "Fauna der Gaskohle und der Kalksteine der Permformation Böhmens." By Dr. Anton Fritsch. Vol. III, part 4. Pp. 105–132, pls. 123–132, with Title-page and Index to Vol. III. (Prague: Fr. Rivnac, 1895.)

WITH the exception of a brief supplement, Dr. Anton Fritsch has now completed his description of the fossil vertebrata of the Permian formation of Bohemia. The latest instalment, received in the middle of December, concludes the third volume of his great work and deals with the Palæoniscid fishes which remained to be treated after the issue of the preceding part a year ago. The systematic descriptions are continued in the usual manner, and there is appended a useful summary of the chief points in the structure of the Palæoniscidæ as the author has observed them.

Most of these fishes discovered in the Bohemian Permian belong to the genus *Amblypterus*, as now generally defined, and Dr. Fritsch recognizes seven species, one of these with no less than six named varieties. *Amblypterus Feistmanteli* and *A. Zeidleri* are described as new species in the part of the work before us. There are beautiful figures of the ornamented head-bones of the variety *A. Rohani* (Heckel); while restored figures of this form, of *A. luridus* (Heckel), *A. obliquus* (Heckel), and *A. Reussi* (Heckel) are also given. The latter are in some respects tentative and incomplete, and we would question the accuracy of the drawing of the anterior dorsal fin-rays in *A. luridus*, as also the diminutive proportions of the circumorbital ring in the same fish. Most welcome additions to our knowledge of details in the osteology of the genus appear throughout the descriptions and figures; and the discovery of tritoral teeth on one of the inner mouth-bones in *A. Feistmanteli* is particularly interesting.

Two small and one large species are doubtfully referred by Dr.

Fritsch to *Acrolepis* (*A. Krejcii*, *A. sphærosideritarum*, and *A. gigas*, Fritsch). The latter is a fine fish considerably more than a metre in length, and the largest known Palæoniscid; Dr. Fritsch even suggests that it is the largest known Palæozoic fish, but it must have been much surpassed in dimensions both by *Rhizodus* and by *Megalichthys intermedius*. A plaster cast of this unique specimen is exhibited in the British Museum (Natural History).

Some fragmentary specimens bearing much resemblance to *Elonichthys* and *Rhadinichthys*, too imperfect (in our opinion) for generic determination, are regarded as indicating a hitherto unknown genus *Pyrogyrolepis*, with the single species *P. speciosus*. This is defined thus:—"Similar to the genus *Gyrolepis*, but dentition with large pointed teeth, between which are small teeth in irregular rows; the large teeth smooth at the apex, beautifully striated at the base, with large pulp-cavity; anterior rays of pectoral and dorsal fins not articulated."

The name *Hemichthys problematica* is proposed for a small skull of doubtful relationships, which may even belong to a Labyrinthodont. A detailed description is promised in the supplement to the next volume.

In his concluding observations on the Palæoniscidæ, Dr. Fritsch particularly emphasizes the difficulty of regarding the degree of arching of the back as a specific character. He instances the variations in this feature in the common carp, which depend much upon the locality and surroundings. He also adds a warning as to the displacement of the fins by different kinds of crushing. In the head he finds that the cranial bones are thickest when least ornamented; thinnest and most irregular when the ganoine is best developed. Large otolites appear in at least one species of *Amblypterus*. With regard to calcified vertebræ, he now considers that his former determination of such elements in the supposed *Phanerosteon* and *Sceletophorus* is very doubtful.

The new part of the "Fauna der Gaskohle" thus equals in interest its predecessors, and bears witness to the same laborious and patient research and attention to minute detail, which characterize the whole of the work. A. S. W.

III.—Memoirs of the American Museum of Natural History. Vol. I, part 2. August, 1895, pp. 74, plates iv to xiii.

In this finely illustrated Monograph Prof. R. P. Whitfield, Curator of palæontology in the American Museum of Natural History in New York City, gives a second instalment of the republication of descriptions of fossils from the Hall collection, from the Report of progress for 1861 of the Geological Survey of Wisconsin, by James Hall. The type specimens, now figured for the first time, are chiefly derived from the Trenton group in Wisconsin. They comprise algae, some of which were previously confounded with Graptolites, such as the noteworthy *Buthograptus laxus*, "an *articulated* marine form" much resembling the living *Caulerpa plumaris* of the Florida coasts; a crinoid, a crustacean (*Illaenus*

taurus), Lamellibranchiata, Gasteropoda, and Cephalopoda. This memoir is published, Mr. Whitfield states, with a view of avoiding a redescription under other names than the original ones, as it is deemed advisable to illustrate these types from the specimens originally used, a course which has been now followed with three exceptions. In Part I of Vol. I Mr. Whitfield, it will be remembered, gave descriptions and figures from the types of Lower Carboniferous Crinoids in the "Hall" collection, of which he is Curator. A. C.

REPORTS AND PROCEEDINGS.

Zoological Society of London.

December 17th, 1895.—Sir W. H. Flower, K.C.B., LL.D., F.R.S., President, in the Chair.

Mr. F. A. Bather read a paper on a remarkable and very beautiful form of fossil crinoid, without a stalk, named *Uintacrinus*. The paper attempted a complete morphological description of *Uintacrinus socialis*, based on specimens from the Upper Cretaceous Beds of Western Kansas, now in the British Museum. The deficiencies of previous accounts were made good, and their errors corrected; this was specially the case with regard to the interbrachials, interpinnulars, brachials, pinnules, and joints. The comparison with other crinoids, thus rendered possible, showed that *Uintacrinus* could not be related either to the Camerata or to the Ichthyocrinidæ. It must therefore be related either to the Palæozoic Inadunata, or to their Mesozoic descendants, the Canaliculata. Among these a process of comparison and elimination left behind only the ascending evolutionary line that contained *Encrinus*, *Dadocrinus*, *Pentacrinus*, and *Apiocrinus*. A simple inspection enabled one to fix on *Dadocrinus* as the one among all known genera that was most nearly related to the ancestor of *Uintacrinus*.

Geological Society of London.

I.—January 8, 1896.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "A Delimitation of the Cenomanian, being a Comparison of the Corresponding Beds in Southern England and Western France." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and William Hill, Esq., F.G.S.

The object of the authors is to compare the beds which form the lower part of the Upper Cretaceous Series in those parts of Southern England and Western France which are nearest to one another. They briefly trace the history of English and French geological research, and remark that even at the present time French geologists are not agreed as to the beds to be included in their "étage Cénomanien."

The authors feel justified in taking the English succession as a

standard, and endeavour to show that the French succession is in accord with it, believing that the confusion of French geologists has arisen from their having taken a set of arenaceous shallow-water beds as the standard of their Cenomanian stage, in a district where these form the local base of the Cretaceous System, and where the typical Albien fauna does not exist.

Commencing with the English sections, they describe such as serve to establish the succession in the Isle of Wight, Dorset, and Devon, pointing out that the Gault and Upper Greensand are everywhere so inseparably united that it is difficult even to assign limits to the component zones; further, that the Lower Chalk is clearly marked off from this group, and that no classification can be accepted in England which does not recognize the clear and natural line of division at the base of the Chalk.

In Devonshire the representative of the Lower Chalk is found in a set of arenaceous deposits which contain a remarkable fauna, some of the fossils being such as occur in the Upper Greensand, some in the Chalk Marl, while many have not been found elsewhere in England, but occur in the Cenomanian of France and in the Tourtia of Tournay. This Devonshire "Cenomian" includes the beds numbered 10, 11, 12, and 13 by Mr. Meÿer in his Beer Head section, Quart. Journ. Geol. Soc., vol. xxx (1874), p. 369.

Passing over to France, the fine section in the cliffs between Cap la Hève and St. Jouin is described in detail, and the bed which is regarded as the base of the Cenomanian by M. Lennier and Prof. A. de Lapparent is shown to be the representative of the Chloritic Marl of the Isle of Wight; the Greensand and the Gault below forming, as in England, a separate and independent group of beds.

An account is then given of a traverse made through the departments of Calvados and Orne as far as Mortagne; succeeded by a brief account of the lateral changes which take place as the Cenomanien is traced through the Sarthe, this being derived from the publications of MM. Guillier and Bizet.

A critical study of the fossils found in Devonshire and Normandy follows, with tabulated lists comparing the Devonshire fauna with that of the French Cenomanian, and the fossils of the Norman Cenomanian with those of the Warminster Greensand and of our Lower Chalk. In this part of the work the Authors have received much assistance from Mr. C. J. A. Meÿer and Dr. G. J. Hinde.

Finally, they claim to have defined the limits of the Cenomanian stage in Western France, and to have shown that this group of beds is simply a southern extension of our Lower Chalk, formed in a shallower part of the Cretaceous Sea and nearer to a coast-line.

2. "The Llandovery and Associated Rocks of Conway." By G. L. Elles and E. M. R. Wood, Newnham College. (Communicated by J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.)

The discovery of beds with *Phacops appendiculatus*, Salt., near Deganwy, and of shales with a fauna of Upper Birkhill age close to the town of Conway, indicates that the break between Ordovician and Silurian is smaller in this area than has hitherto been supposed.

In the paper a full description of the representatives of the Birkhill, Gala (Tarannon), and Wenlock beds is given, and the distribution of the fossils (chiefly graptolites) in the various subdivisions is recorded. Many of the graptolites are forms which have been described from Swedish deposits, but have hitherto been unrecorded in this country.

3. "The Gypsum Deposits of Nottinghamshire and Derbyshire." By A. T. Metcalfe, Esq., F.G.S.

The gypsum deposits of these counties occur in the Upper Marls of the Keuper division of the Triassic system. The Author describes their occurrence in thick nodular irregular beds, large spheroidal masses, and lenticular intercalations, and their association with satin-spar, alabaster, selenite, and anhydrite.

II.—January 22nd, 1896.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Speeton Series in Yorkshire and Lincolnshire." By G. W. Lamplugh, Esq., F.G.S.

Further work on the Speeton section, while extending our knowledge of the palæontological details, has fully sustained the results of the Author's previous investigations. The rapid attenuation and final disappearance of the Speeton Series in a westerly direction in Yorkshire is discussed, and though the available evidence is held to be insufficient to demonstrate the exact conditions, it is shown that, contrary to the accepted view, the lower zones are probably the first to die out, and are overstepped or overlapped by the higher divisions, since at Knapton, fourteen miles inland, only the upper zones of the coast-section can be proved to occur, as shown by the presence of marls with *Bel. minimus* passing upward into the Red Chalk, and by the fossils preserved in the Old Collection which include *Hoplites Deshayesii* under the name of *Amm. Knaptonensis*, Bean MS., and a few others.

The ferruginous sands locally occurring beneath the Red Chalk on the western edge of the Yorkshire Wolds are recognized as agreeing in all respects with the Lincolnshire Carstone; and Mr. A. Strahan's conclusions as to the relations of this division to the Red Chalk are confirmed both in Yorkshire and in Lincolnshire.

In Mid-Lincolnshire all the palæontological zones of Speeton are identified and traced, the presence of the leading zonal types of the Cephalopoda readily establishing the general correlation proposed by Professor A. Pavlow and the Author, in spite of the greatly modified lithological aspect of the deposits, and the corresponding modification of their fauna. The chief features of this correlation, which differs in many respects from that adopted by Professor Judd and the Geological Survey, are as follows:—(see table on p. 88).

Kimmeridge Clay.

In Lincolnshire in at least one instance the boundary of a palæontological zone, which is the true synchronal line, is shown not to pursue the same stratigraphical horizon throughout its course,

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proving that sediments of different character were accumulated at the same time in comparative proximity to each other. The inherent divergence between the stratigraphical and palæontological methods in geology is thus once more illustrated.

It is suggested that the derivative character of the band of phosphatic nodules at the base of the Spilsby Sandstone is not well established, and that the fossils of the 'so-called' pebbles probably represent an original fauna poorly preserved in nodules formed during a temporary pause in the sedimentation.

The 'Zone of *Bel. lateralis*' (*Série Speetono-russe* of Pavlow) is shown to bridge the space between undoubtedly Jurassic and undoubtedly Lower Cretaceous strata; but according to the recent results of Professor A. Pavlow, if the accepted classification of other areas is to be upheld, the division between the two systems must be placed high enough to include this zone in the Jurassic, in spite of the local inconvenience of this arrangement.

Speeton.		Lincolnshire.
	RED CHALK.	
Zone A. Passage Marls	=	Carstone (? in part or wholly).
B. Zone of *Bel. Brunsvicensis*	=	Tealby Limestone and its southerly equivalents (also ? the lower part of the Carstone).
C. Zone of *Bel. jaculum*	=	Tealby Clay of the Wold escarpment (the lower portion of the zone doubtfully represented).
D. Zone of *Bel. lateralis*	=	'Tealby Clay' of the outliers west of Spilsby (Hundleby Clay), Claxby Ironstone and Spilsby Sandstone.
E. 'Coprolite-bed'	=	Nodule-bed at base of Spilsby Sandstone.

2. "On some Podophthalmous Crustaceans from the Cretaceous Formation of Vancouver and Queen Charlotte Islands." By Henry Woodward, LL.D., F.R.S., P.G.S.

This paper contains descriptions of several Crustaceans from the Cretaceous Coal-bearing strata of Vancouver and Queen Charlotte Islands, sent to the Author by J. F. Whiteaves, Esq., F.G.S., Palæontologist to the Geological Survey of Canada, und two from the Museum of the Geological Society of London.

After giving a brief notice of the deposits from which the nodules containing these crustacean fossils have been derived, and the authors who have written upon them, Dr. Woodward describes (1) a new *Callianassa* which he names *Callianassa Whiteavesii*; (2) an Anomalous Brachyuran, which he names *Homolopsis Richardsoni*; (3) a new Corystid, named *Palæocorystes Harveyi*; and (4) a new Cancer, named *Plagiolophus Vancouverensis*.

3. "On a Fossil Octopus, *Calaïs Newboldi* (J. de C. Sby., MS.), from the Cretaceous of the Lebanon." By Henry Woodward, LL.D., F.R.S., P.G.S.

The specimen to which the Author's attention was obligingly drawn by Mr. C. Davies Sherborn, F.G.S., is in the Museum of the Geological Society, and was obtained by Major Newbold, and named in 1846 in MS. by the late Mr. J. de Carle Sowerby, *Calaïs Newboldii*, who added on the label:—"Ceph. Octopoda. Genus ineditum. Abdomen alis triangularibus instructum. E. strato calcareo (*tertiario*) Montis Libani a (D.) Newbold effossum.—1846. J. de Carle Sowerby."

The Author described the specimen in detail, and retained for it the genus and species proposed by Mr. Sowerby.

4. "On Transported Boulder-clay." By the Rev. Edwin Hill, M.A., F.G.S.

The 'mid-glacial' sands of the cliffs between Yarmouth and Lowestoft are overlain at Corton by Chalky Boulder-clay. But further north than Corton some masses of the same clay occur in the interior of the cliffs, surrounded by the sands in undisturbed stratification, but passing into them by strings and patches such as suggest the melting off of enveloping ice. They have probably been floated and dropped there.

Again, gravels lying in a valley of Chalky Boulder-clay in West Suffolk (Cockfield, etc.), and indicating considerable denudation of the Clay, yet have some patches and sheets of that Clay overlying them as if carried down or slipped down from higher ground.

This may explain some anomalous positions of Boulder-clay noted by writers. The Lowestoft observations suggest that Chalky Boulder-clay was being manufactured in one locality simultaneously with 'mid-glacial' sands in another.

CORRESPONDENCE.

A GEOLOGICAL SURVEY OF EGYPT.

Sir,—When passing recently through Cairo, I was informed by Lord Cromer of the intention of the Egyptian Government to undertake a Geological Survey of that country, and a few details of the proposed work may not be without interest to your readers. I may state in the first place that this survey is to be undertaken independently of any anticipation of the discovery of valuable minerals; in fact, quite independently of any utilitarian object, but with a desire to advance the interest of science in Egypt, and to put that country in line with other civilized States. At the same time should the survey result in the development of mineral substances, this will be so much gain. The first chief of this new department will be Captain Lyons, R.E., F.G.S., who, as your readers will recollect, recently read a suggestive paper before the Geological Society of London on Egyptian Geology,[1] and who, while carrying out the duties of his position as an officer of the Egyptian army, has taken advantage of every opportunity to extend his knowledge of the geological structure of the Nile Valley and the adjoining desert

[1] "On the Stratigraphy and Physiography of the Libyan Desert of Egypt," Q.J.G.S., No. 200 (Nov., 1894).

tracts. I understand that Captain Lyons intends to visit England early in the ensuing summer in order to select a staff of young geologists to work under him in Egypt. Ample provision has been made in the estimates for equipment, tents, camels, and attendance. It will of course only be possible to carry on outdoor work during six months in the year; but the geological structure of the country is of great interest, though on the whole, simple; and the formations are distributed on a large scale. For young geologists who wish to extend their knowledge of other countries the work ought to prove attractive, and with due care, will be healthy. Camping in tents in the desert is, as I can state from experience, exceedingly enjoyable, and when to this is added the delight of riding on camels and donkeys, there is nothing more to be said in order to secure numerous volunteers for the work! EDWARD HULL.

ERRATUM AND NOTE TO ARTICLES ON EOZOÖN.

SIR,—I observe in the beginning of the second paragraph of my Article in December 1895, p. 545, an error which may puzzle some readers. The words "*old calcite and serpentine lagoons*" should be "calcite and serpentine layers." A less important error is the substitution of the name "Lorne" for "Lowe" in the description of Fig. 2 in my first Article in October 1895, p. 447.

In the second Article I should perhaps have mentioned that in the Glauconite Limestone of Levis (Ordovician), and in that of Kempfen, Bavaria (Eocene), as well as in Cretaceous and Modern greensands, while some grains of glauconite fill cavities of fossils, others, and often the great majority, are independent and amorphous. Thus in mode of occurrence the hydrous silicates of later limestones do not differ from that in the Grenville Limestone.

January 3, 1896. WM. DAWSON.

ON THE TRUE MEANING OF THE TERM BOLDERIAN.

SIR,—Professor Dewalque, of Liége, in a letter you have lately published (1st December, 1895), criticizes the use I made of the term "Bolderien," established by Dumont, for some beds of the Belgian Tertiary formation. But this courteous censure seems to me without sound ground, and I think he has misunderstood Dumont's statements.

If we turn to the Journal of the Royal Academy of Brussels, for 1849, where Dumont created the term "Bolderian," we read: "The Bolderian system is divided into two stages; one is a marine stage in which the lower part consists of glauconiferous sands, and the upper part is composed of yellow sands, in these come, in order, the fossiliferous sands of the Bolderberg; the other stage is a fresh-water formation, consisting of sands and lignite, of which traces are found under the Campinian deposit."

There is no doubt about this, the type of the Bolderian system, in its lower part, is indicated as composed of marine fossiliferous sands found in the hill of Bolderberg, near Hasselt, and includes the fossiliferous bed so well known in that locality.

This opinion is repeated in various other publications; we can see in the explanation of the geological map of Belgium, published by Dumont, in 1892, the following lines: "Miocene=System Bolderian — gravels, glauconiferous sands, white sands, shelly gravels, and various other sands."

In Dumont's private notes, published not many years ago by M. M. Mourlon, we find the same version. Dumont says in his description of the Bolderberg Hill: "This gravel contains pebbles of flint from the size of a nut to the size of an egg, and a great many shells more or less well-preserved; they were living during the time of the deposition of the sand in which they are found."

We could multiply these quotations, but when Mr. Dewalque says that the Bolderian is a white unfossiliferous sand, he speaks of *his* Bolderian, but not of the original Bolderian of Dumont. On the other hand, the Bolderberg fauna is clearly Upper Miocene, we find that this fauna is extremely close to the fauna of Edeghem sands, near Antwerp, of which the malacological fauna has been described by Nyst, in 1861, as true Miocene. More than 90 per cent. of the species are common to the two localities, and we think there is good ground to say that the Bolderian was contemporaneous with the Anversian. The term Anversian was introduced into the science by Mr. Cogels, in 1879, to indicate the level of the Edeghem sand, or lower black sands of Antwerp.

We will give the names of some of the most typical shells found in the Bolderberg:—

Murex aquitanicus, Grat.
Terebra Basteroti, Nyst.
Cancellaria cancellata, L.
,, *acutangularis*, Lk.
,, *imbricata*, Hoernes.
Dipsaccus Brugadinus, Grat.
Pleurotoma asperulata, Lk.
,, *denticulata*, Bast.
,, *ramosa*, Bast.
,, *festiva*, Dod.
Pectunculus pilosus, L.
Conus Dujardini, Nyst.
Voluta Bolli, Kock.
Ancillaria obsoleta, Br.
Oliva Dufresnei, Bast.
Turbo muricatus, Duj.
Natica Josephinia, Risso.
Venus multilamella, Lk.
Cytherea chione, Lk.
Corbula carinata, Duj.
Corbulomya complanata, Sow.
Ostrea crassissima, Lk.

It will be at once clear to any geologist that the age of this fauna must be Miocene; it certainly cannot be Oligocene. This is a warm (southern) fauna, very distinct from the cold or temperate fauna of the Diestian deposits. The scruple of Mr. Dewalque is based on the fact that in the Bolderberg Hill, the fossiliferous bed (sometimes ferruginous) rests upon a thick mass of white sand, and is covered by a great mass of ferruginous sandstone pertaining to the Diestian formation, and Mr. Dewalque does not seem perfectly sure whether the fossiliferous bed pertains to the lower mass, or to the upper one. But we have seen that the old stratigraphists, such as Dumont, had classified the fossiliferous beds with the white sands; and since that time the best contemporary geologists, as Mr. Gosselet, have adopted the same conclusion, saying that the fossiliferous sands have nothing to do with the Diestian or upper beds.

More recently Mr. Van den Broeck discovered at Waenrode, near

Diest, in the Bolderian white sands, a fossiliferous bed not near to the top of the formation. Last summer the Belgian Geological Society made an excursion to those localities, with a view to observe again the exact position of the fossiliferous bed. The sections were exposed afresh, and all the geologists present, Mr. Lorié, from Utrecht, Mr. Lohest, pupil of Mr. Dewalque, Mr. Vincent, palæontologist, and many other distinguished Belgian geologists, also the writer of the present letter, came to the same conclusion, namely, that the fossiliferous bed is inclosed in the white sands, exactly as had been stated by Dumont many years ago.

When my honoured friend, Prof. Dewalque, says that in the eastern direction, near the valley of the Rhine, the white Bolderian sands contain Tongrian fossils, this is only an affirmation, but no evidence in favour of this statement has ever been produced. We should be very pleased to make the acquaintance of any geologist who has been so fortunate as to follow step by step the Bolderian sands from Hasselt to the Rhine!

The most recent observations seem to prove, on the contrary, that Dumont made in his Bolderian a great inversion; his Upper fluvio-marine stage is really the Lower one, and the marine shales are the Upper. The fluviatile Bolderian has been recognized in boring under Campine and Limbourg, and probably it is associated with the Rhenan lignites; it might take the name of Aquitanian. But this question is not yet perfectly solved. Last month Mr. Van den Broeck came to the conclusion that the Bolderian sands were very close to the Upper Rupelian sands, and that all these sands were united, by repeated alternation, with the Rupelian clay (*Argile de Boom*) and by no means form a good horizon. But even if the fluviatile Bolderian is not valid and is a bad subdivision, containing sands which can be better classified in three or more different stages, it remains always a good marine Bolderian, a sound type well characterized by its palæontology, and indicated by its stratigraphy. We think that we can, without any hesitation, maintain the old name of "Bolderian" in its true, original acceptation.

G. F. Dollfus, F.C.G.S.

Paris, 10 *Janvier*, 1896. Président de la Société Géologique de France.

OBITUARY.

HUGH MILLER, F.R.S.E., F.G.S.

Born July 15th 1850. Died January 8th, 1896.

It is with great regret that we record the death of Mr. Hugh Miller, F.R.S.E., F.G.S., of the Geological Survey of Scotland. Bearing the same name as his distinguished father, the author of "The Testimony of the Rocks," "The Old Red Sandstone," etc. Mr. Hugh Miller inherited a taste for geological pursuits, and joined the Geological Survey in 1874. Labouring at first among the Carboniferous Rocks and Glacial Drifts of Northumberland, he was subsequently transferred to the Geological Survey of Scotland, and worked at the Old Red Sandstone around Cromarty, rendered

classic by the researches of his father. Later on he mapped portions of the Ancient Schists, Old Red Sandstone, and Drifts of Eastern Sutherlandshire. He was author of the picturesquely-written book entitled "Landscape Geology," and of papers on River Action and Glacial Phenomena. Among the more important of these papers the following may be mentioned:—"Tynedale Escarpments: their Pre-glacial, Glacial, and Post-glacial Features," 1880; "River Terracing: its methods and their results," 1884; and "On Boulder-Glaciation," 1884." All who enjoyed Mr. Miller's friendship will feel that they have lost a kind-hearted, though keenly sensitive, friend. Strongly imbued with a love of Nature and natural phenomena, he at the same time kept himself in touch with the intellectual life of our time. He leaves a widow and a son, fifteen years of age, who is being educated at Fettes College.

PROFESSOR LUDWIG RÜTIMEYER, M.D.

Foreign Member of the Geological Society of London.

BORN 1825. DIED NOVEMBER 26TH, 1895.

HERR PROFESSOR DR. LUDWIG RÜTIMEYER was born at Biglen in the Commenthal, Canton Bern, in 1825. His father was a parish clergyman, and afterwards Superintendent of the Orphanage at Bonn. Ludwig was educated in the High School and Gymnasium of that town, and in 1842 went to the University of Berne, where he studied theology, with the intention of following his father's profession. Having developed a taste for comparative anatomy, no doubt partly through the influence of his friend Peter Merian, the Basel Palæontologist, he forsook his theological studies, and took up medicine. Afterwards he visited many of the chief European cities, and in Paris in 1850 he became acquainted with Elie de Beaumont, and in 1852 he came to London, which he again visited in 1877, In 1854 he took up academical teaching in the Berne University, and in the following year accepted the newly established Chair of Zoology and Comparative Anatomy at Basel, where he remained till his death.

His first work, "Vom Meere bis nach den Alpen," was published on his return from his travels in 1854; after this he issued a long series of Memoirs, characterized by the great accuracy and detail of their observations, and the wide philosophical grasp and far-reaching deductions made from them.

Some of the more important of these memoirs are:—"Untersuchungen der Thierreste aus dem Pfahlbauten in der Schweiz," 1860, in which he gives an account of the earlier races of some of the domestic animals, and shows that while in the Lake-dwellings of Stone Age the remains of wild animals predominate, showing that the inhabitants lived mainly by the chase, in the later settlements, made after the use of metal was discovered, the inhabitants relied chiefly on various domesticated animals for food.

Another important paper is "Beitrage zur Kentnisse der Fossilen Pferde und zu einer Vergleichenden Odontographie der Hufthiere in Allgemeinen," 1863; this may be regarded as laying the foundation

of that detailed comparative morphology of the teeth, in which the homologies of the several cusps is considered, and from which the American palæontologists have been able to draw very important conclusions as to the phylogeny of many groups of mammals.

In a paper entiled "Ueber die Herkunft unserer Thierwelt eine Zoogeographisch Skizze," 1867, Rütimeyer gives a masterly account of the distribution of the mammalia, showing the relations of the fossil faunas to one another and to the recent forms. It is a testimony to his sagacity that the great additions to our knowledge of this subject have confirmed most of his conclusions, and have rendered very few untenable.

He was elected a Foreign Member of the Geological Society of London in 1882.

Up to the time of his death Prof. Rütimeyer maintained a lively interest in all scientific researches, and carried on his correspondence to the last. He died at Basel on 26th November, 1895.

E. A. WÜNSCH, F.G.S.

BORN 1822. DIED NOVEMBER 19TH, 1895.

THIS gentleman was one of the original members of the Glasgow Geological Society, which was founded in 1858, and he has served the office of Vice-President several times from 1858 to 1881, when he left Glasgow to reside at Carharrack, Scorrier, Cornwall, where he died November 19th, aged 73 years.

The most important service which he rendered to geological science was his discovery in 1865 of *erect trees buried in volcanic ash at Arran.* These trees were discovered in the Lower Carboniferous strata of the north-eastern part of Arran in the sea-cliff, about five miles north of Corrie, near the village of Laggan. Here strata of volcanic ash occur, forming a solid rock cemented by carbonate of lime and enveloping trunks of trees, determined by Mr. Binney to belong to the genera *Sigillaria* and *Lepidodendron.* Sir Charles Lyell mentions that he visited the spot in company with Mr. Wünsch in 1870, and saw that the trees with their roots, of which about fourteen had been observed, occur at two distinct levels in volcanic tuffs, parallel to each other, and inclined at an angle of about 40°, having between them beds of shale and coaly matter seven feet thick. It is evident that the trees were overwhelmed by a shower of ashes from some neighbouring volcanic vent, as Pompeii was buried by matter ejected from Vesuvius. The trunks, several of them from three to five feet in circumference, remained with their stigmarian roots spreading through the stratum below, which had served as a soil. The trees must have continued for years in an upright position after they were killed by the shower of volcanic ash, giving time for a partial decay of the interior, so as to afford hollow cylinders into which the spores of plants were wafted. These spores germinated and grew, until finally their stems were petrified by carbonate of lime, like some of the remaining portions of the wood of the original *Sigillaria* tree-trunks.—"Lyell's Students Elements," 4th edition, 1885, pp. 496, 497.

The Hon. Walter B. D. Mantell, F.G.S.—We regret to record the loss of this excellent naturalist and geologist, who died at Wellington, New Zealand, September 7th, 1895, in his 75th year. He was the eldest son of the well-known geologist, Dr. G. A. Mantell, F.R.S., and settled in New Zealand in 1840, where he was for years a member of the Colonial Government. We hope to give a fuller notice of his work later on.

MISCELLANEOUS.

Search for Coal in East Anglia.—The Eastern Counties Coal Boring Association has abandoned the hope of finding coal at Stutton on the Stour, where the bore has been carried down 1,525 feet. The consulting geologists and the mining engineer expert are agreed that the rocks reached are evidently older than the Coal-measures. The next trial bore is likely to be made either some ten miles to the north, about Bramford, in Suffolk, or the same distance to the south, near Bentley or Weeley, in Essex. At present the latter site seems to be most in favour.—*St. James Gazette*, November 28th, 1895.

Geology of the San Francisco Peninsula.—Observations made by Mr. A. C. Lawson on the geology of the San Francisco Peninsula show the presence of seven groups of rocks or "terranes." (1) Crystalline limestone, of unknown age; (2) Granite, referred to as the Montara granite, which is intrusive in the crystalline rock, is perhaps of post-Jurassic age, and is spoken of as "a great batholite, which has invaded the crust from below"; (3) The Franciscan series, probably of Cretaceous age, in which there are not only grits, conglomerates, shales, great beds of sandstone, and some volcanic rocks, but also foraminiferal limestones, and peculiarly-bedded Radiolarian cherts; (4) Sandstone of Eocene age; (5) Monterey series (Miocene); (6) Merced series (Pliocene); and (7) Terrace formations (Pleistocene and later). The Radiolarian cherts of the Franciscan series are hard, flinty, siliceous rocks, of varied colour, and they occur in thin sheets (two to four inches thick) with partings of shale; but they are not of great extent. The beds are, in places, several hundred feet thick, and they are interbedded with sandstones. In many cases the cherts are true jaspers, and sometimes they pass into a quartz-rock resembling vein-quartz. The Radiolaria appear as minute dots quite distinct from the matrix. The suggestion that these cherts are deep-sea deposits is negatived by their interbedding with sandstones. Nor can they be considered as mainly organic. The silica of the cherts seems to have been originally an amorphous chemical precipitate, deposited at local centres on the sea-bottom, in which Radiolarian remains were sporadically entombed. The most probable origin of the bulk of the silica is considered by Mr. Lawson to have been sub-marine siliceous springs of solfataric character. (*American Geologist*, June, 1895.)

Western Australia.—Mr. Harry Page Woodward, J.P., F.G.S., F.R.G.S., F.I.Inst., Assoc. Memb. N. of Engl. Inst. Mining and Mech. Eng., formerly Assistant Government Geologist, South Australia, and who for the past eight years has filled the important post of Government Geologist for Western Australia, has resigned the Government Service and joined the staff of Messrs. Bewick, Moreing, and Company, Mining Engineers, of London and Western Australia. Mr. Woodward's services will be available for reporting and advising on all Western Australian properties through Messrs. Bewick, Moreing, and Co.—"Mining World and Engineering Record," January 11th, 1896, p. 57. "The British Australasian and New Zealand Mail" of January 9th, writes as follows:—"When I was in Western Australia in 1891, I had the pleasure of seeing a good deal of Mr. Woodward, and a more efficient public official I never met with. Apart from his professional qualifications he is a man of fine physique, inured to fatigue, and of most agreeable manners. Nobody understands the Colony geologically and otherwise better than he does, and there can hardly be an acre of the settled districts which he has not inspected. The worst of it is Governments cannot, or will not, pay efficient officers at the same rate which private firms are able, and indeed compelled, to offer for first-class services, and as a natural result the tendency is to rob the Civil Service of its brightest ornaments. However, the services of Mr. Woodward will not be lost to the Colony, and their value may be even increased now that with his great abilities he has a free hand. I heartily congratulate Messrs. Bewick, Moreing, and Co. on their latest acquisition."

New Geological Survey Map.—The Geological Survey has just issued, for the first time, a map *printed in colours*. This is Sheet 12 of the four-mile to one inch map of England and Wales. It includes the London Basin and great part of the Wealden area. As previously published, coloured by hand, the price of this sheet was 10*s*. 6*d*. The price is now 2*s*. 6*d*. This will in itself be an advantage to purchasers; and moreover there is another advantage, and it is that colour-printed maps, when carefully prepared, are accurate and uniform; whereas in hand-coloured maps uniformity in colouring cannot be rigidly maintained, and the colourist may, at times, omit to colour certain outliers and inliers. We understand that Her Majesty's Stationery Office has issued this new map as an experiment, and that if successful the companion sheets of this useful map of England and Wales, will likewise be printed in colours, with a corresponding reduction in price. We should like to see the system of colour-printing adopted with regard to the new series of one-inch maps now in course of publication by the Geological Survey, for the system is almost universally adopted abroad, and with success.